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# RECORDS OF TASMANIAN CETACEA: No. II

## A LARGE SCHOOL OF THE PILOT WHALE, GLOBICEPHALUS MELAS (TRAILL, 1809), STRANDED AT STANLEY, NORTH WESTERN TASMANIA, IN OCTOBER, 1935

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PLATES I-XI

ABSTRACT

The largest Cetacean stranding recorded in Tasmania occurred in 1935, when a school of 200-300 individuals of the Pilot Whale, *Globicephalus melas* (Traill, 1809), came ashore at Circular Head Peninsula, North West Coast. Observations made in the course of a visit to the scene of the stranding are here recorded and discussed. Matters dealt with include the following: general history of the stranding (number in school, causes of stranding, disposal of carcases); foetuses; sex ratio; behaviour; dentition; detailed dimensions of 20 individuals (10 males, 10 females); standard length distribution, and variation of standard length with sex and age; year-classes, and age-length equations; some dimensions and some body ratios in relation to standard length, and their correlation with sex and age; axial growth regions, and axial growth gradient; general form; coloration.

### Family DELPHINIDAE

### Genus **Globicephalus** Hamilton, 1836

### **Globicephalus melas** (Traill, 1809)

*Delphinus melas* Traill, *Journ. Nat. Phil.*, xxii, 1809, p. 81.

The cosmopolitan Pilot Whale, Caa'ing Whale, or Blackfish has a well established place in the Tasmanian faunal list (see contribution No. I in the present series: *Rec. Queen Vict. Mus.* I. 1. 1942).

During the night of 13th-14th October, 1935 (probably early in the morning of Monday, 14th) a school of between two and three hundred individuals of this species was stranded at Stanley, North Western Tasmania.

On Tuesday, Mr W. Cunningham, Taxidermist, Tasmanian Museum, Hobart, and the writer proceeded to Stanley, arriving there in the late afternoon, and remaining till Thursday, 17th, when the progress of arrangements for the disposal of the carcases rendered further investigations impracticable. During our visit Mr Cunningham secured two complete skeletons and two additional skulls (roughly fleshed, with local assistance, on the beach), and, as a result of opening up about a dozen females, obtained three foetuses: one of the latter has been dealt with by Pearson (1936, p. 190), who has also made reference to the present observations.

## SITE OF STRANDING

The stranding of at least the major part of the school occurred on a sandbank lying some little distance (distance varying greatly in accordance with the state of the tide) from Tatlow's Beach, adjacent to the township of Stanley (Lat. 40° 46′ S., Long. 145° 17′ E.), on Circular Head Peninsula, North Western Tasmania.

The locality has already been described and mapped in contribution No. I (Scott, 1942).

## CONVENTIONS

Individual specimens are referred to throughout by field numbers (nos 1-22).

All dimensions are recorded in centimetres: save in one or two cases, where ambiguity might arise, the name of, or an abbreviation for, the unit is omitted, for typographical clarity and economy, from measurements cited in the body of the paper.

The majority of measurements are made between parallels, normal to the longitudinal axis of the animal. Exceptions to this rule are *(a)* and *(b)*, specified in this paragraph. *(a)* The following dimensions follow the curve of the body: girth, interocular distance, gonidial angle to eye. *(b)* The measurement of the mouth cleft is an oblique one, taken with flexible steel rule laid hard against cheek-line from most anterior point of mouth cleft to gonidial angle. An approximation to distance, between parallels, between levels of tip of snout and gonidial angle may be derived from the data afforded by no. 7, in which oblique length of mouth cleft, measured as above, is 31·5, while the direct length, between parallels, is 23·0—*i.e.*, direct length is, in this case, 73·0 per cent of oblique length.

Unless otherwise stated, 'length to' means 'length from most advanced part of head to' (in this species the most advanced part of head is not necessarily, as it is in most whales, the free end of upper or lower jaw, frequently being part of the 'forehead'). Length to eye, and length to blowhole are measured to anterior border; length to vent is measured to middle of opening. Length of pectoral is measured from axilla to tip; breadth of pectoral is maximum breadth, measured at right angles to the long axis of the fin.

Dimensions for maximum girth are based on measurement of maximum semi-girth doubled, practical considerations usually making the measuring of the whole girth a difficult (and uncertain) proceeding. The measurement 'base of dorsal' must be accepted with some reserve: while a reasonably good estimate can be made of the point of origin, the lapse of the fin caudad into the general body profile is so gradual as to make a determination of its termination necessarily somewhat uncertain. 'Height of dorsal' means vertical height of tip of fin above general body-level at about middle of base of fin.

The distance, between parallels, from most advanced part of head to anterior margin of caudal notch is termed standard length, and is represented by the symbol LS.

## GENERAL OBSERVATIONS

The whales appear to have been first observed by Mr J. Trethewie, who was awakened at 3.45 a.m. on Monday, 14th October, by a curious whistling sound, which he described (*The North Western Advocate*, 15/10/'35) as being 'like the sound of escaping gas'. Going outside, Mr Trethewie, whose farm is on a hillside (part of the Green Hills) behind Tatlow's Beach, saw the whales piled up in a huge black mass, about half an acre in extent, on a bank of sand. In Plate I, fig. 1 is reproduced a photograph taken not very far from, but lower down the hill than, Mr Trethewie's residence: at the time this record was secured, a large portion of the school still lay on the sandbank on which the whales originally became stranded. Figs 2-4, in the same plate, show the whales washed closer inshore.

High tide on the night of the 13th-14th October occurred at 12.33 a.m. on the 14th: the whales therefore apparently became trapped about midway between high and low tide levels. The night was described (*The North Western Advocate*, 15/10/'35) as being 'beautiful, calm, and moonlit [full moon, 12th October], with only a light southerly wind'. 'My stock', stated Mr Trewethie, 'was panic stricken, and cattle and horses were herded in close proximity to my house, instead of as usual in the distant paddocks. No calling would make the horses come to the stables, which remained deserted in the morning. Even the fowls were obviously frightened, and the dogs cringed about the yards the whole morning'.

The whistling and the bellowing of the school attracted residents of the town soon after daybreak. With the rising of the tide later in the day (high tide, 1.02 p.m.), many of the whales became scattered along the coastline for a distance of about half a mile: but it is stated that even after the immediately succeeding low tide one group of 110 individuals remained clustered on an area of sand measuring about 40 yards by 20 yards, the animals then being about three chains nearer the shore than when first seen early in the day.

Newspaper statements that the animals, when in a few feet of water, lashed furiously with their tails, in an endeavour to escape, and that a few did succeed in gaining the sea are generally discounted by eye-witnesses. In this connexion, the following paragraph from *The Circular Head Chronicle*, of Wednesday, 23rd October, is worthy of quotation. 'The further the whale news went the more sensational it grew. One Tasmanian daily paper had a story of seventy "escaping" and another described "frantic efforts to escape", of which of course there were none. These efforts of the imagination, combined in the Melbourne *Argus* on Wednesday of last week, became "Townspeople watched a procession of nearly three miles long making for the sea, while in the shallows scores of whales lashed the water in their futile efforts to escape."'

The history of the next few days is merely that of the continual alteration of the disposition of the whales along the shores, sandspits, and sandbanks with changes in the tide-levels. Some five or six days later one whale was noticed on the shore right at the township of Stanley, and individuals were seen some miles eastward along the coast from the site of the original stranding: the first specimen certainly drifted to its new position, and the occurrence of occasional specimens in the direction of Black River Beach is probably accounted for in the same way. A few carcases floated out to sea on each tide, some being seen passing Stanley wharf, and others being reported by shipping off Rocky Cape.

There is an unconfirmed report that one individual came ashore in West Bay (see map—Plate VIII, fig. 2—accompanying contribution No. I: Scott, 1942).

## NUMBER IN SCHOOL

An early account (*The North Western Advocate*, 16/10/'35) placed the total number in the school at 209. In the course of a day-by-day account, the local newspaper, under the heading of Saturday, stated, 'The most that can be said is that about 200 were buried. Mr W. H. Davison says probably a few more than 200, Mr L. W. Brooks 246. Mr W. H. Davison walked along Black River Beach and around the inlet to count the stragglers, making them fifty, including one at Brickmakers Bay and one right in Stanley between the old wharf and the new' (*The Circular Head Chronicle*, 23/10/'35). With the addition of the widely scattered carcases counted by Mr Davison, the total number in the school would thus appear probably to be in excess of 300.

At 5.30 a.m. on Wednesday, 16th, I counted 194 scattered thickly along about two miles of beach, with others dotted about the channel, and a few stranded along the eastern shore of East Inlet, making a total in sight of about 230, with a strong presumption that there were a number not then visible.

A formal tally made by the health authorities, published some weeks later, gave the number of carcases dealt with as 291, and this figure may be accepted as a close approximation to the number of animals stranded.

This is the largest school of whales of any species recorded as being stranded on the Tasmanian coast. Other extensive strandings in the vicinity of Stanley in recent years include 37 Sperm Whales, *Physeter catodon* Linné, 1758, at Perkins Island, in 1911; about 70 'dolphins' (*?Delphinus delphis* Linné, 1758), near Tatlow's Beach, about 1923; in May, 1936, 21 specimens (Circular Head), in June, 1936, about 60 specimens (Walker's Island), and in July, 1937, about 80-100 specimens (Circular Head) of the False Killer, *Pseudorca crassidens* (Owen, 1846): see contribution No. I (Scott, 1942).

There are many records of the stranding in various parts of the world of large schools of the Pilot Whale, which is a notably gregarious species, occurring in schools that not infrequently comprise from two hundred to three hundred individuals, and that are said sometimes to number as many as two thousand. It is commonly stated that the members of a herd blindly follow a leader, after the manner of a flock of sheep, whence the name Pilot Whale. If the pilot runs into shoal water, and becomes stranded, the remainder of the school follow him, and often suffer the same fate. The origin of another vernacular name, Caa'ing Whale, derived from *caa*, to drive or to lead, is traced by some writers to this habit of following a leader, while others consider the term refers to the ease with which large numbers of this species may be driven ashore. Beddard (1900) states that the name Grindehval, sometimes employed in Europe for this whale (a herd being termed Grind), is derived from *grind*, which signifies lattice work. 'Its application to the whales is apparently the placing [in the Faröe Islands] of a line of boats across the mouth of a bay where a herd of the Cetaceans has run toward the shore'.

Mention may here be made, in passing, of some of the records given by Hamilton (1852) and Harmer (1927, 1929) of extensive strandings, and wholesale captures, of this species. In 1664, in two excursions, the inhabitants of the Faröe Islands killed about one thousand individuals. In 1799 about 200 ran ashore in Feltar, one of the Shetland Islands. In February, 1805, 190, and in March of the same year 120 more, out of a herd of about 500, were forced ashore on the same spot in Uyea Sound in Unst. In 1806, 92 were stranded in Scalpa Bay, Orkney; in the winter of 1809-1810, 1110 approached the shore of Hvalfiord, Iceland, and were captured; in 1814, 70 were chased ashore near the village of

Bloubalzblance, on the coast of Bretagne; in 1814, 150 were driven into Balta Sound, Shetland, and there despatched; in 1832, 98 were captured in the Island of Lewis; in 1845, 1540 were killed, in two hours, at Shetland Island; in 1911, about 50 were stranded at Penzance; in 1920, 328 individuals were killed at the same time in the Faröe Islands. Over the period of three hundred years from 1584 to 1883, the number recorded as being killed at the Faröe Islands alone amounted to 117,456 individuals.

## CAUSES OF STRANDING

No indications of disease, and no signs of injuries other than those incidental to running aground, were observed. An adequate explanation of the stranding appears to be afforded by the known propensity of this species to venture close inshore in a compact school, considered in conjunction with the character of the locality, which, with its shallow waters strewn at low tide and even at half tide with many emergent sandbanks and sandspits, forms an effective natural trap for creatures of such size and habits.

## DISPOSAL OF CARCASES

The disposal of the carcases presented a problem that was tackled promptly and efficiently, the plan of operations, initiated locally, being considerably expedited as the result of a visit to Stanley made by the Hon. the Chief Secretary, Mr T. D'Alton, accompanied by Mr Riley, Chief Inspector, Public Health Department. It was estimated by the Chief Secretary that the total cost of the operations would not exceed £500.

The general course of procedure adopted was as follows. Carcases were dragged to the water line, mostly by bullock teams, to a lesser extent by motor lorries; towed along the inlet, generally with the aid of row-boats, in some cases by small yachts and motor launches; dragged ashore again; and finally buried, some in trenches dug just above the high water mark, the majority in hastily enlarged natural hollows lying in the shoreward side of a line of strand-fringing sand dunes, near a spot 2-3 miles from the township, known locally as Dodge Cars (see Plate VIII, fig. 2, accompanying contribution No. I). The three upper and the three lower photographs reproduced here in Plate II show some of the successive phases of the plan adopted for the removal of the carcases.

On Wednesday, 23rd October, some seventy whales were floated up the inlet at high tide, and were hauled ashore as nearly as possible to highwater mark at the selected burial site. The digging of trenches was started, hand labour being found more expeditious than the earth-scoop.

On the Thursday the work was continued, and by the evening all but ten of the whales had been floated out of the channel, up the inlet: of the ten left, four were still alive. Of these ten whales, nine were successfully dealt with the next day: one specimen (identified locally as the pilot), though bleeding from contact with the rocks, resisted when taken in tow by a motor boat, and after being carried for some distance, set off downstream, against the current, towing the boat that was supposed to be towing it, till at last the tow-rope snapped, and the animal returned to the angle in the channel, where it had to be left for the day. 'Mr Clark, Health Inspector, stayed in Stanley to superintend the disposal of the carcases. Mr W. H. Davison was in charge of thirteen men floating the carcases up the channel and Messrs Hardstaff, public works inspector, and L. W. Brooks, lent by the Circular Head Council, took charge alternately of 17 men, working shifts of 6½ hours, digging trenches and hauling the whales up the beach' (*The Circular Head Chronicle*, 23/10/'35). Near the burial ground a Public Works Department tractor and three bullock teams hauled the carcases into position.

In its day-by-day review of the progress of the disposal of the carcases, *The Circular Head Chronicle*, of Wednesday, 23rd October, observed, under the heading of Friday, 19th, 'Friday saw a cool change mercifully, and the burial began, the tractor doing fine work, hauling the carcases from where they had been left the day before into the graves, and nearly half those collected on the point were dealt with that day, showing that the danger was past. As a trench was filled the carcases were liberally sprinkled with quicklime, and then another trench was dug beside them, the spoil being thrown onto the first lot'.

Under the heading of Saturday, the newspaper account states, 'By mid-day on Saturday all the carcases that had been concentrated at the cemetery were neatly tucked into their big graves, but the last trench containing fifty or sixty was left uncovered for tourists to see, and smell, on Sunday'. On Sunday, 'the excursion train from Devonport was packed, and tourists were still arriving in cars, lorries and buses as well. The whales could be smelt from the main road'. On Monday the removal of about fifty widely scattered individuals was begun.

The stranding naturally excited considerable interest. The Board of Advice granted a half holiday to enable schools for some distance round to inspect the whales; the running of a special train from Devonport has already been noted; and the local newspaper stated that visitors 'must have averaged from well over a thousand a day for the week, and business people in the town felt the benefit'.

## Skeletons and Skulls

The skeleton of a female (no. 7, carrying an advanced foetus), and the skull of a male (no. 11) were secured for the Tasmanian Museum, Hobart; and the skeleton of a male (no. 1), and the skull of a female (no. 10) for the Queen Victoria Museum, Launceston.

## Foetuses

From about a dozen females opened up, three foetuses, all of the order of 100 cm. in length, were obtained by Mr Cunningham. These came from nos 7, 21, 22, of LS 380, 387, 440 respectively. Some proportions of one foetus (female; LS 102) have been recorded by Pearson (1936, p. 190). No indications of early embryonic stages were found.

## Sex Ratio

Of 194 individuals sexed by the writer, 80 (41 per cent) were males, 114 (59 per cent) were females. The sample was a random one to the extent that it comprised all individuals readily accessible on the stretch of beach covered.

## Condition of Females

Of the larger females, perhaps half exhibited indications of being, or of being about to be, in milk. In a number of individuals marked distension of the whole mammary region, accompanied by intumescence and oscitancy of the mammary slits, was observable, and in some cases the mamma itself, usually entirely concealed, was rendered clearly visible by the wide gaping of the lips of the slit. In a few specimens active lactation had occurred (presumably as the result of fright) after stranding, the milk having trickled down in one or two narrow streams across half the ventral surface as the animal lay on its side.

These facts, taken in conjunction with the presence in the school of a considerable number of small individuals, seem to indicate that quite a fair proportion of the adult females had calved comparatively recently. It is also noteworthy, that, as recorded above, three advanced foetuses were met with, while no indications of the presence of embryos in early stages were observed.

As the result of examination of conjectured age-classes, it is suggested below that members of age-group A (two males, of standard length 231, 245) were probably about 8-9 months old, and were approaching the end of the suckling period; while the foetuses observed are calculated as being 3-4 months short of parturition.

## CONDITION OF MALES

Among many of the larger males the penis, as frequently obtains in stranded whales, was protruded and much distended: in individuals of LS 400-500 its length was about 75, its proximal diameter about 17. Not infrequently it lay in contact with the abdomen for part of its length: as far as was noted, it was invariably considerably curved. In the younger examples, the smaller penis—approximately 3 long in no. 1 (LS 346)—lay prone, directed forwards, in its groove.

## BEHAVIOUR

The majority of specimens cast ashore (after dispersal from the original scene of stranding) on the rocks near the high tide line on Tatlow's Beach had either the head or the caudal fin pointing more or less directly inland. Among the groups scattered about on the sand, there were no obvious indications of any prevailing orientation of the body-axis.

Up till about the Wednesday evening, many individuals still exhibited considerable vitality, occasionally lashing vigorously with the hinder portion of the body, and, if trodden upon, or otherwise provoked, giving a sudden convulsive heave, often attended by a grunting noise.

In certain individuals of either sex a fairly fluid discharge, usually dark greenish in colour, had been emitted, doubtless under stress of fear, from the vent: in several specimens, noted on Wednesday, this fecal matter, which was fairly copious and showed a marked tendency to froth, was audibly voided at irregular intervals.

At no time did we observe any disposition on the part of individuals floated off from the sandbanks or rocks by tide, or dragged by bullock teams down the beach to the channel, to make any real attempt to reach deeper water, or otherwise to escape. Though the animals often found themselves in a fathom, or more, of water, they contented themselves with moving slowly around in a restricted area, or, apparently helpless, and, in some instances, unable to regain, or maintain, their position of balance, rolled about, without making any noticeable progress, to the accompaniment of much puffing and snorting.

## DENTITION

One half only of the mouth is considered throughout.

Dental formulae of nos 1-20: $\frac{10}{9}$, $\frac{10}{10}$, $\frac{13}{11}$, $\frac{12}{11}$, $\frac{10}{10}$, $\frac{8}{0}$, $\frac{10}{9}$, $\frac{11}{11}$, $\frac{11}{10}$, $\frac{10}{9}$, $\frac{10}{7}$, $\frac{12}{11}$, $\frac{10}{11}$, $\frac{10}{11}$, $\frac{12}{11}$, $\frac{10}{9}$, $\frac{11}{9}$, $\frac{11}{10}$, $\frac{9}{10}$, $\frac{10}{9}$, respectively. In the smallest individual (no. 6, LS 231) no mandibular teeth were yet erupted. In the formulae for nos 6, 15, 17, 20 are included, respectively, 3, 2, 3, 2 maxillary teeth barely above the alveolar line, these evidently being in two of the animals (nos 6, 15) just erupted, and in the other two worn down. Extreme variates $\frac{8\text{-}13}{0\text{-}11}$; mean $\frac{10{\cdot}50}{9{\cdot}40}$; standard deviation $\frac{1{\cdot}14}{2{\cdot}46}$ (greater dispersion in lower jaw accounted for by no. 6, which has no mandibular teeth erupted: for the remaining 19 individuals mean for lower jaw is 9·89, giving standard deviation of 1·10, a value closely approximating that for upper jaw). There are 14 individuals with more upper than lower teeth; 3 with more lower than upper; 3 with same number of upper and lower teeth. On the data, the difference in numbers in upper and lower jaws is not statistically significant. Among 10 females, however, no less than 8 have one more tooth in the upper than in the lower jaw; and the 2 other individuals (one with $\frac{10}{10}$, one with $\frac{10}{11}$) are both large animals in which one or more teeth may perhaps have been lost.

For 10 males we get: extremes $\frac{8\text{-}13}{0\text{-}11}$ (excluding no. 6, $\frac{9\text{-}13}{7\text{-}11}$); mean $\frac{10{\cdot}20}{8{\cdot}70}$ (excluding no. 6, $\frac{10{\cdot}44}{9{\cdot}67}$); standard deviation $\frac{1{\cdot}33}{3{\cdot}31}$ (excluding no. 6, $\frac{1{\cdot}37}{1{\cdot}68}$). For 10 females we have: extremes $\frac{10\text{-}12}{9\text{-}11}$; mean $\frac{10{\cdot}80}{10{\cdot}10}$; standard deviation $\frac{0{\cdot}92}{0{\cdot}88}$.

Differences in number between maxillary, total, and mandibular teeth in the sexes give $t = 0{\cdot}7$, $1{\cdot}2$, $1{\cdot}3$, respectively: as the value for 'fair significance' (one chance in a hundred) for 20 specimens is 2·88, these differences are to be attributed, on the data, to chance. It is, of course, possible that the investigation of larger series would establish the differences as real: an examination of the extremes, means, and standard deviations for the two sexes, when considered in relation to LS (see Table I), strongly suggests, however, that such differences between males and females as are found are primarily a function of age, in which variable the male sample is considered (see below) to have a more extended distribution than the female sample.

The smallest total number of teeth in any individual examined is 8 (specimen no. 6); the next smallest total is 17 (specimen no. 11): these two individuals (both males) are the smallest, and are regarded as being the youngest, in the whole sample of 20 specimens.

The largest total is 24 (specimen no. 3, a large male, of LS 571), the next largest total among males being 22 (specimen no. 8, of LS 387). Among females, three specimens (nos 12, 15, 4, of LS 274, 318, 398, respectively) have each 23 teeth.

It is worthy of note that, when females are arranged, by length classes (hence, presumably, by age-groups), in ascending order of size, the mean number of total teeth runs in a descending series—namely (for four groups of mean LS 274, 322, 388·3, 444), 23·0, 22·0, 20·7, 20·3. Among males this relation does not obtain, three length-class of mean LS 238, 366·5, 568·6 having mean number of total teeth 12·5, 20·5, 20·5.

The evidence afforded by the three smallest males, of LS 231, 245, 368, suggests the probability that (in this sex, at least) the maxillary erupt earlier than the mandibular teeth.

Harmer (1927, p. 37) records for this species $\frac{10}{10}$ teeth in a specimen 20 feet 6 inches in length, and 9 and 11 teeth in the lower jaws of specimens 11 feet, and 15 feet 3 inches in length, respectively. He gives the normal number as 'about 10' [in each side of jaw], with which the present counts closely agree.

## Dimensions

In Table 1 on page 14 are recorded 18 dimensions of each 20 individuals—10 males, 10 females.

The procedure adopted in making the measurements has already been specified (see Conventions, above).

For convenience of reference the sexes have been segregated, and each group has been arranged in descending order of LS (specimen nos 1-20 are field numbers).

## Standard Length

The term standard length has been defined above (see Conventions).

The largest and smallest individuals readily accessible were measured: from an inspection of inaccessible individuals, however, it is in the case of the minimum certain, in the case of the maximum possible, that the values recorded do not represent the extremes of the school. It was stated in the press (*The North Western Advocate*, 15/10/'35) that the length of the whales (probably measured from most advanced part of head to tip of flukes) ranged from 4 feet 6 inches (*c.* 137 cm.) to 25 feet (*c.* 762 cm.): this estimate includes smaller and larger individuals than any measured by the writer.

While detailed measurements were made of 20 individuals only, the standard lengths of two others (nos 21, 22; two females in calf, of LS 387, 440, respectively) were measured.

For LS of these 22 individuals we find: minimum 231, maximum 589, mean 423·25, median 411·00, standard deviation (using $n$-1) 103·23. In the case of the 20 specimens (nos 1-20) that were made the subject of detailed metrical study the corresponding values are 231, 589, 424·23, 411·00, 112·29, respectively.

The maximum length of 589 cm. (about 19 feet 4 inches) observed is well below the extreme value for this species, which may attain a length of 28 feet (Harmer, 1927, p. 36).

## Table I

Globicephalus melas (Traill, 1809): Dimensions of 10 Males and 10 Females (in cm.)

| Dimension | Males | | | | | | | | | | Females | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. 13 | No. 17 | No. 16 | No. 3 | No. 19 | No. 2 | No. 8 | No. 1 | No. 11 | No. 6 | No. 18 | No. 14 | No. 5 | No. 20 | No. 4 | No. 10 | No. 7 | No. 9 | No. 15 | No. 12 |
| Length to caudal notch .... | 589 | 576 | 572 5 | 571 | 560 | 543 | 387 | 346 | 245 | 231 | 464 | 452 | 440 | 424 | 398 | 388 | 380 | 326 | 318 | 274 |
| Length to eye .... .... .... .... | 46 | 38.5 | 41.5 | 43 | 46 | 41.5 | 35.5 | 34.2 | 28.5 | 21.5 | 33.5 | 37 | 34 | 35.5 | 33.5 | 33.5 | 31 | 29 | 29.5 | 31.5 |
| Diameter of eye .... .... .... | 4 | 4.2 | 3.8 | 4 | 3.8 | 3.5 | 3.1 | 3.5 | 2.6 | 2.8 | 3.6 | 3.4 | 3.3 | 3.5 | 4 | 3 | 2.9 | 3.3 | 3 | 3.3 |
| Interocular distance .... .... | 106 | 91 | 101 | 89.2 | 94 | 85 | 79 | 72.6 | 59 | 55 | 73 | 83 | 75 | 79 | 69 | 76 | 71 | 60 | 66 | 58 |
| Length of mouth cleft .... | 40 | 37 | 38 | 37 | 38 | 37 | 31.5 | 33.5 | 24 | 23.2 | 35 | 32 | 33 | 34 | 34 | 33.5 | 31.5 | 30 | 29.5 | 27 |
| Gonidial angle to eye .... .... | 12.5 | 11 | 10.5 | 11.5 | 10 5 | 10.8 | 9 | 9.5 | 7.5 | 6.3 | 9.7 | 10 | 10.5 | 8.5 | 9.2 | 8.6 | 10 | 8 | 9 | 8 |
| Length to blowhole .... .... | 51.5 | 44 | 47 | 47.5 | 49 | 45.5 | 39 | 38.7 | 30.5 | 23 | 38 | 44 | 41 | 42 | 41 | 37 | 38 | 32 | 37.5 | 36 |
| Length to origin of pectoral | 82 | 80.5 | 80 | 80 | 79 | 73 | 61 | 61.5 | 49 | 44 | 66 | 68 | 68 | 65 | 65 | 64.5 | 62 | 56 | 49 | 54 |
| Length of pectoral .... .... | 125.5 | 123 | 113.5 | 112 | 123 | 105 | 65.3 | 63.9 | 43 | 42 | 94 | 87 | 71 | 80.5 | 77.5 | 73 | 71.5 | 59 | 62.5 | 49 |
| Max. breadth of pectoral . | 31 | 31 | 29 | 30 | 30.3 | 30 | 18.5 | 18.2 | 12 | 11.7 | 24.5 | 22 | 20 | 21 | 21 | 20.5 | 23 | 16.5 | 16.4 | 14.5 |
| Length to origin of dorsal | 174 | 164 | 163.5 | 166.5 | 176 | 165 | 117 | 119 | 93 | 82.5 | 143.5 | 153 | 142.5 | 134 | 135 | 118.5 | 126.5 | 111 | 112 | 102 |
| Base of dorsal .... .... .... .... | 129 | 119 | 114 | 109 | 97 | 106 | 58 | 62.5 | 32 | 45 | 90 | 85.5 | 80 | 82 | 74 | 64 | 71 | 57 | 56 | 49 |
| Height of dorsal .... .... .... | 42 | 39 | 33 | 41.5 | 41 | 37 | 21 | 22.3 | 19 | 15 | 33 | 29 | 29.5 | 25 | 26.5 | 23.5 | 26 | 22 | 23 | 17.5 |
| Max. girth .... .... .... .... .... | 310 | 289 | 270 | 275 | 308 | 286 | 201 | 211 | 146 | 130 | 265 | 273 | 218 | 234 | 216 | 199 | 217 | 186 | 198 | 164 |
| Length to level of max. girth .... .... .... .... .... .... | 175 | 153 | 150 | 155 | 163 | 162 | 102 | 108 | 80 | 73 | 132 | 130 | 124 | 128 | 135 | 114 | 121 | 100 | 130 | 97 |
| Length to vent .... .... .... .... | 365 | 355 | 334 | 360 | 340 | 335 | 230 | 195 | 163 | 150 | 273 | 271 | 273 | 264 | 257 | 242 | 236 | 202 | 197.5 | 185.5 |
| Length from caudal notch to level of posterior margin of flukes .... .... .... .... | 10.5 | 10 | 10 | 9 | 8 | 10.2 | 10 | 9 | 8 | 8.5 | 7 5 | 9 | 9 | 9 | 11.5 | 9 | 11 | 15 | 10 | 10.5 |
| Spread of flukes .... .... .... | 146 | 128 | 124 | 136 | 134 | 130 | 79 | 74.8 | 48 | 48 | 110 | 92 | 101 | 91 | 81.6 | 76 | 81 | 62 | 62 | 57 |

## VARIATION OF STANDARD LENGTH WITH SEX

For 10 males we have, as regards LS, minimum 231, maximum 589, mean 462·1, median 551·5. For 12 females we have minimum 274, maximum 464, mean 390·9, median 393·0 (for the 10 females of which detailed measurements were made—*i.e.*, excluding nos 21, 22, included in the 12 individuals just specified—the corresponding values are 274, 464, 386·4, 393·0).

Taking, in sequence, maximum, mean, median, we find the values for males (10 specimens) exceed those for females (12 specimens) by 125·0, 71·2, 158·5, or by 27, 18, 40 per cent, respectively. In the light of the conclusions reached below on the distribution of the sample as regards year-classes, it becomes apparent that the best measure of the normal excess of standard length of males over that of females is afforded by the first of the three rather widely differing values just given, namely, that for the maximum. An excess of 27 per cent in length found by comparison of the largest individual male with the largest individual female agrees well with an excess of 28 per cent calculated from the mean standard lengths of the largest male and female length-classes, the individuals comprising which are regarded as being coeval.

I am not acquainted with any published data on the relative sizes of the sexes in the Pilot Whale. An excess, among adults, of male over female length by about 10-40 per cent is, however, usually found in Odontocetid whales.

## STANDARD LENGTH DISTRIBUTION

Females, with a standard deviation of 59·07 (12 specimens) or 64·77 (10 specimens), form a much more compact group, as regards standard length, than males, of which the standard deviation is 144·84 (10 specimens).

On making allowance for the fact that the male mean standard length considerably exceeds that of the female, and expressing the data as coefficients of variability (standard deviation of length as a percentage of mean length), we find the value for females, namely, 15·1 per cent (12 specimens) or 16·8 (10 specimens) is still only about half that for males, namely, 31·3 per cent (10 specimens). This marked divergence is to be attributed primarily to the fact that the male sample probably includes one more year-class than the female sample (see below), and secondarily to the fact that the rate of growth of males probably exceeds that of females, with the result that, over a comparable range of age-groups, the difference between the extremes of class-means is greater in males than in females. That there still remains, even when allowance is made for these factors, a small but significant residual difference of variability between the sexes is possible. On calculating the coefficients of variability for three male length-classes A, D, G, and for four female length-classes C, D, E*a*, F*a*, specified in the next section, and weighting the results for number of individuals in classes, we obtain a general mean coefficient of variability for males of 4·08, for females of 2·55. The difference between the samples is statistically significant, and hence there is probably a greater inherent tendency towards individual variability, in regard to standard length, in males than in females.

With length-classes of 100, having central values 250, 350 . . . , the distribution of the whole series of 22 individuals is: 250, 3 cases; 350, 8; 450, 5; 550, 6, the mode thus falling in the 350 class. With length-classes of 25, having central values 237·25, 262·5 . . . , the mode (5 cases) falls in class 387·5. The value of the mode derived from the formula mode = median — 3 (mean — median) is 371·25.

Though the sample is small, an analysis of distribution suggests the existence of seven length-classes, specified in Table II on p. 17.

The classes E*a* and F*a*, each of which includes one specimen of which the only dimension recorded is LS, are provided with lower case italic suffixes to permit of their distinction from classes E*b* and F*b*, which, with the exclusion of the two individuals in question (nos 21, 22), are employed below in discussions on proportions.

Of these seven length-classes, the least compact is D (standard deviation 28·99); those least definitely differentiated are D and E (percentage increase of mean LS of D over that of E only 5·9): the remaining classes are well differentiated. The recognition of classes D and E receives support from considerations, noted below, on age-groups and on variations of proportions with standard length: it has, moreover, the practical merit of permitting complete sex-segregation.

## YEAR-CLASSES

Assuming the seven length-classes A-G specified in Table II are valid, there are various possible interpretations of their likely significance when regarded as year-classes.

While, on the rather meagre data available, the whole matter must remain, at this stage, decidedly speculative, the following tentative analysis—represented diagrammatically, with LS means of length-classes A-G plotted against time in years, in Plate III—is not inconsistent with the facts, and does not appear incompatible with the probabilities. *(a)* female foetus of standard length 102, recorded by Pearson (1936, p. 190) about 7-8 months old; *(b)* foetus to be born about January-February, being then of standard length round about 160; *(c)* smallest female measured (group B, Table II) about $1\frac{2}{3}$-$1\frac{3}{4}$ years old; *(d)* females of groups C, E*a*, F*a* aged about $2\frac{2}{3}$-$2\frac{3}{4}$, $3\frac{2}{3}$-$3\frac{3}{4}$, $4\frac{2}{3}$-$4\frac{3}{4}$ years, respectively; *(e)* smallest male measured (group A) about $\frac{2}{3}$-$\frac{3}{4}$ year old; *(f)* males of groups D and G aged about $2\frac{2}{3}$-$2\frac{3}{4}$, $4\frac{2}{3}$-$4\frac{3}{4}$ years, respectively; *(g)* youngest pregnant females noted (nos 7, 21, of LS 380, 387) aged, at beginning of pregnancy, about 3 years, the animals then being of standard length of about 337; *(h)* remaining pregnant female noted (no. 22, of LS 440) aged, at beginning of pregnancy, about 4 years, then being of standard length of about 403; *(i)* lactating females (see above, CONDITION OF FEMALES) still suckling individuals of the age-group A, represented in the metrically examined sample by nos 6 and 11 (lactation probably soon due to cease).

The following brief comments may be made on this tentative interpretation of the admittedly rather scanty data. After some consideration, the following have been adopted as definitive probabilities in the construction of the graph in Plate III—largest males and largest females (which constitute the numerically largest group in the case of either sex) regarded as coeval; the four female length-classes regarded as representing successive year-classes; males taken to be consistently larger than females. Lydekker (1911, p. 854) has observed of this species, 'The young, of which there is generally one at a birth, are said to be born in late summer, and suckled through the winter'. Gestation period taken as 10-12 months (about the modal value for Cetacea). Standard length of whale at birth would be about 39 per cent of mean length of females of group E*a* at date of parturition, or about 35 per cent of length of largest female measured. Little appears to be known of the values of these ratios among the Odontoceti generally, probably on account of their relatively small economic value, but in the commercially important Sperm whale, *Physeter catodon* Linné, 1758, the calf at birth is stated to be about 30-40 per cent of the length of the mother: among the Mystacoceti the length at

TABLE II

GLOBICEPHALUS MELAS (TRAILL, 1809): SPECIFICATION OF PROBABLE LENGTH-CLASSES AMONG 22 SPECIMENS

| Length-Class | Sex | Field Nos of Specimens | Standard Length (in cm.) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Mean | Standard Deviation | Percentage excess of mean LS over mean LS of preceding class | Percentage excess of mean LS over mean LS of preceding class of same sex |
| A | Male | 6, 11 | 231 | 245 | 238·0 | 9·90 | | |
| B | Female | 12 | 274 | 274 | 274·0 | | 15·1 | |
| C | Female | 9, 15 | 318 | 326 | 322·0 | 5·66 | 17·5 | 17·5 |
| D | Male | 1, 8 | 346 | 387 | 366·5 | 28·99 | 13·8 | 54·0 |
| E*a* | Female | 4, 7, 10, 21 | 380 | 398 | 388·3 | 7·41 | 5·9 | 20·6 |
| F*a* | Female | 5, 14, 18, 20, 22 | 424 | 462 | 444·0 | 14·97 | 14·3 | 14·3 |
| G | Male | 2, 3, 13, 16, 17, 19 | 543 | 589 | 568·6 | 15·63 | 28·1 | 55·1 |

birth ranges from about 25 per cent to upwards of 40 per cent of fully adult length. Direct readings from the graph, extrapolating as necessary, give excess of length of male over female at 1, 2, 3, 4, 5, years as about 12, 10, 16, 22, 29 per cent, respectively (actual excess of mean of group G over mean of group F*a*, both of a presumed age of $4\frac{2}{3}$-$4\frac{3}{4}$ years, is 28·1 per cent: see above, VARIATION OF STANDARD LENGTH WITH SEX). The rapid increase in length and the early attainment of sexual maturity envisaged in the present tentative analysis would not seem to be in any way exceptional: a Fin Whale, *Balaenoptera physalus* (Linné, 1758), marked by the *Discovery*, and recorded at the time as a calf accompanying its mother, was found when captured 2½ years later to be a female 20·97 metres (about 69 feet) in length (Hardy, 1940); and sexual maturity at two years appears probable in some species.

## STANDARD LENGTH IN RELATION TO AGE

If we assume the validity of the interpretation of length-classes as year-classes given above, and, further, assume that length is a linear function of age (the graph of Plate III suggests the latter assumption applies reasonably closely in the case of females, but is less satisfactory in the case of males), we can arrive at an approximate relation between standard length and age.

On the basis of the assumptions noted, the age-length equation (treating end-points as definitive co-ordinates for solution, and taking age of individuals of group A as 8 months) for males is $y = 6{\cdot}\dot{8}x - 175$, and for females $y = 5{\cdot}2x - 171$, where $y$ is standard length in centimetres, and $x$ is age in months. The length at birth thus arrived at (male 175, female 171) is perhaps somewhat high, but the excess, if any, probably does not exceed 10 per cent.

The equations given fit the data, as far as mean values of standard length are concerned, to within about 10 cm. as a maximum divergence. In the case, at least, of the present sample, therefore, they not only provide a close approximation for mean standard lengths of age-groups, but also make possible the estimation of individual length, at a given age in months, to within a limit of perhaps plus or minus 0·5 m.

Individuals of this species do not appear often to exceed about 24 feet in standard length, but many reach 28 feet. These dimensions would be attained by males, under the conditions of growth here specified, at about 7 and at about 8 years of age.

## SOME DIMENSIONS IN RELATION TO STANDARD LENGTH

In Plates IV-VI nineteen dimensions—comprising the direct measurements (other than LS) in Table I, together with two derived dimensions, namely, length to end of dorsal (length to origin of dorsal plus dorsal base), and postanal length (standard length minus length to vent)—are plotted on LS. The plotting of the mean values of the seven length-classes A, B, C, D, E*b*, F*b*, G specified in Table II, in preference to values of individuals constitutes a convenient compromise in procedure, in which the sacrifice of a larger number of co-ordinates is offset by the resultant smoothing of the curves. The problem of individual variation, which has its own special interest, has not, however, been neglected; and statistics of individual variations are provided below in a discussion of the dimensions dealt with in this section. Where, as obtains in the majority of cases, differences in proportion between the sexes are of sufficient magnitude and consistency to yield curves of appreciable visual distinctness, separate curves for males (solid line) and for females (broken line) are shown: in other cases (confined to Plate VI) co-ordinates for both sexes are joined to form a single curve (dots and dashes).

Examination of the curves reveals in most cases a reasonable approach to linearity, and linearity is assumed throughout the course of the discussion of the present section. It seems, however, not unlikely that, with additional data available, the presence of logarithmic functions might in some cases be demonstrable.

Let $\frac{x_2 - x_1}{x_1} = k$, and $\frac{y_2 - y_1}{y_1} = k_1$, where $x_1$, $y_1$ are co-ordinates of any given dimension in length-class A, and $x_2$, $y_2$ the corresponding co-ordinates in length-class G. Then, with linearity of the graph assumed, $k$ and $k_1$ constitute measures of the relative increase of standard length and the relative increase of the given dimension, in the population sampled. Let $\frac{k_1}{k} = m$. Then $m$ is the relative increase of the given dimension expressed as a ratio of the relative increase of standard length. Hence when $m$ is less than, equal to, greater than, unity, the rate of growth of the given dimension is, respectively, less than, equal to, greater than, the rate of growth of the whole animal in length (strictly, in standard length). The value of $m$ is, of course, inversely proportional to the value of the ratio given dimension in standard length.

The various dimensions plotted against LS in Plates IV-VI are considered seriatim below.

*(i)* LENGTH TO EYE. (Plate IV, *a*). *Relative Growth.* Solving for $k_1$ (here, and in the dimensions considered below) for male means of groups A and G, we get relative increase $= k_1 = 0{\cdot}71$. Relative increase in LS (groups A and G) $= k = 1{\cdot}39$. Hence $m = \frac{k_1}{k} = 0{\cdot}51$, that is, length to eye does not increase as rapidly as standard length, or, in other words, length to eye in LS, as compared with standard length, is relatively greater in smaller individuals (the ratio length to eye in LS decreases with increasing general size of animal). *Sexual Variation.* Inspection of the graph shows there is no consistent difference between the sexes in the length to the eye in individuals of comparable LS (comparison is feasible, without extrapolation, only between LS limits of 274 and 445). *Individual Variation.* Statistics of the ratio dimension in LS (males, 10 specimens, first; females, 10 specimens, in brackets): max. 14·96 (13·58), min. 8·60 (8·70), mean 12·09 (11·71), median 12·49 (11·91), standard deviation 1·929 (1·377), coefficient of variability (per cent) 16·0 (11·8). *Remarks.* Length to eye consistently exceeds slightly the oblique length of mouth cleft (average excess 6 per cent), and is smaller than length to blowhole by an average amount of 3 per cent.

*(ii)* LENGTH TO ORIGIN OF PECTORAL. (Plate IV, *b*). *Relative Growth.* Length to pectoral decreases relatively with increasing LS, $k_1$ being 0·70, and $m$ 0·50. *Sexual Variation.* No consistent difference between sexes. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 7·44 (7·03), min. 5·00 (5·07), mean 6·54 (6·23), median 7·10 (6·30), standard deviation 0·924 (0·538), coefficient of variability 13·8 (8·6). *Remarks.* Eye-pectoral interval is about equal to preorbital length. Rate of growth of pre-pectoral region is about the same as that of pre-ocular region, namely, one-half of that of the animal as a whole.

*(iii)* LENGTH TO ORIGIN OF DORSAL. (Plate IV, *c*). *Relative Growth.* Length to dorsal decreases relatively with increasing LS, $k_1$ being 0·92, and $m$ 0·66. *Sexual Variation.* From the graph, female measurements are seen consistently to exceed male measurements (over the comparable range in LS), the excess averaging 4 per cent. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 3·51 (3·27), min. 2·63 (2·69), mean 3·19 (3·01), median 3·20 (2·98), standard deviation 0·472 (0·182), coefficient of variability 14·7 (6·0). *Remarks.* While a comparison of the ratio length to origin of dorsal in LS for the whole series of 20 specimens metrically examined does not yield a statistically significant difference between the sexes in the conventional sense that a $t$ test does not give a probability of 0·1, or less, it seems likely that male and female graphs showing a difference of magnitude and consistency of the order of the present example probably point to a real difference in proportion between the sexes. If, indeed, we treat the curves themselves as data, and investigate the difference of the means over the effective range of LS (using for females the values derived from the co-ordinates of the four length-classes B, C, E*b*, F*b*, and for males the direct readings from the curve, taken at the relevant ordinates), we do obtain a statistically significant difference for the sexes.

*(iv)* POSTANAL LENGTH. (Plate IV, *d*). *Relative Growth.* Postanal length increases relatively with increasing LS, $k_1$ being 1·93, and $m$ 1·39. *Sexual Variation.* From the graph, male measurements are seen consistently to exceed female measurements, the excess ranging (at plotted points for females) from about 5 to about 19 per cent, and averaging about 10 per cent. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 2·99 (3·10), min. 2·30 (2·43), mean 2·61 (2·68), median 2·61 (2·64), standard deviation 0·206 (0·183), coefficient of variability 8·7 (6·8). *Remarks.* This derived dimension is included here in view of its special interest as being the only axial dimension (other than dorsal base), among those for which data are available, that has a value of $k_1$ greater than unity: the significance of this circumstance in a study of body proportions at different ages is discussed in a separate section on axial growth.

*(v)* MAXIMUM GIRTH. (Plate IV, *e*). *Relative Growth.* Maximum girth decreases relatively with increasing LS, $k_1$ being 1·10, and $m$ 0·79. *Sexual Variation.* The graph shows a general, but (group E*b*) not consistent, excess of female over male dimensions, the average excess being about 2·5 per cent. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 2·12 (2·02), min. 1·64 (1·61), mean 1·88 (1·78), median 1·90 (1·75), standard deviation 0·156 (0·120), coefficient of variability 8·3 (6·8). *Remarks.* On the whole, the ratio of girth to length is a fairly constant one.

*(vi)* LENGTH TO VENT. (Plate IV, *f*). *Relative Growth.* Length to vent decreases relatively with increasing LS, $k_1$ being 1·22, and $m$ 0·88. *Sexual Variation.* Graph shows female measurements consistently exceeding male measurements, the excess ranging from about 2 to about 7 per cent, and averaging about 5 per cent. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 1·77 (1·70), min. 1·50 (1·48), mean 1·63 (1·61), median 1·62 (1·61), standard deviation 0·787 (0·059), coefficient of variability 4·8 (3·7). *Remarks.* See note on *(iv)*, postanal length.

*(vii)* SPREAD OF FLUKES. (Plate V, *g*). *Relative Growth.* Spread of flukes increases relatively with increasing LS, $k_1$ being 1·77, and $m$ 1·28. *Sexual Variation.* The slight, and not wholly consistent (see group B), male superiority in measurements is probably not significant. *Individual Variation.* Statistics of the ratio

dimension in LS, as before: max. 5·10 (5·26), min. 4·0 (4·21), mean 4·52 (4·80), median 4·56 (4·84), standard deviation 0·374 (0·337), coefficient of variability 8·3 (7·2). *Remarks.* The proportionally greater size of spread of flukes in adult individuals is paralleled by a similar increase, of almost exactly the same magnitude, in length of flipper, these two dimensions probably being correlated mechanically.

*(viii)* LENGTH OF PECTORAL. (Plate V, *h*). *Relative Growth.* Length of pectoral increases relatively with increasing LS, $k_1$ being 1·75, and $m$ 1·26. *Sexual Variation.* No consistent difference between sexes. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 5·92 (6·20), min. 4·55 (4·94), mean 5·20 (5·36), median 5·13 (5·29), standard deviation 0·438 (0·353), coefficient of variability 8·4 (15·1). *Remarks.* See note on *(vii)*, spread of flukes. Length of pectoral is less than total spread of flukes by about 6 per cent. Though length of pectoral increases more rapidly than LS, the relative increase is slight, the fin being 17·9 per cent of LS in group A (males of mean LS 238·0), and 20·6 per cent of LS in group G (males of mean LS 568·6): there is thus in this species nothing comparable with the remarkable elongation of the pectoral with advancing age, noted by Lötken, cited by Harmer (1927), in the Killer, *Orcinus orca* (Linné, 1758). Harmer has described a male killer about 30 feet in length in which the flippers measured 6 feet 8 inches by 3 feet 7 inches, thus considerably exceeding in absolute size those of a Sperm Whale of the largest size. 'Their growth had been mainly due to an enormous increase in the size of the cartilaginous parts of the phalanges and carpal elements, the bony parts of these structures having increased relatively little' (Harmer, 1927, p. 34). In young males and in females of all ages of *Orcinus orca* the flippers are small and weak, their length being about one-ninth of LS, as against about one-fifth of LS in the fully adult male. It is of interest to note that in the sample of *Globicephalus melas* here examined no constant difference in length of pectorals is found to characterize either sex, and the small mean difference observable in the curves over a not very extensive range of LS is, if significant, which is decidedly doubtful, in the form of an excess of female over male measurements.

*(ix)* MAXIMUM BREADTH OF PECTORAL. (Plate V, *i*). *Relative Growth.* Maximum breadth of pectoral increases relatively with increasing LS, $k_1$ being 1·54, and $m$ 1·12. *Sexual Variation.* Graph shows female measurements consistently less than those of males, the difference averaging about 23 per cent. Statistics of the ratio dimension in LS, as before: max. 20·93 (22·00), min. 18·10 (16·52), mean 19·29 (19·41), median 19·01 (19·17), standard deviation 0·891 (1·416), coefficient of variability 4·7 (7·2). *Remarks.* The rate of increase of breadth of pectoral, as compared with length of pectoral—see *(viii)*—is about 12 per cent less, the fin becoming, with increasing age, relatively longer in comparison with length of animal, but narrower in proportion to its own length.

*(x)* BASE OF DORSAL. (Plate V, *j*). *Relative Growth.* Base of dorsal increases relatively with increasing LS, $k_1$ being 1·91, and $m$ 1·38. *Sexual Variation.* Graph shows female measurements consistently exceeding male measurements, the excess averaging about 7 per cent. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 7·66 (6·06), min. 4·57 (5·16), mean 5·56 (5·49), median 5·19 (5·94), standard deviation 0·940 (0·280), coefficient of variability 16·9 (5·1). *Remarks.* This is the only preanal axial dimension recorded that increases relatively more rapidly than LS. The base of the fin exceeds twice its height by an amount varying from 13 per cent in length-class A to 44 per cent in length-class G. The difficulty experienced in securing an accurate measurement of this dimension has been referred to earlier in the section on conventions.

*(xi)* HEIGHT OF DORSAL. (Plate V, *k*). *Relative Growth.* Height of dorsal decreases relatively with increasing LS, $k_1$ being 1·29, and $m$ 0·93. *Sexual Variation.* No significant difference between sexes. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 2·21 (2·13), min. 1·81 (1·82), mean 2·00 (1·95), median 2·02 (1·94), standard deviation 0·181 (0·099), coefficient of variability 4·2 (4·1). *Remarks.* In being relatively longer (higher) in juveniles than in adults, this fin manifests a character opposite to that of the other fins.

*(xii)* LENGTH TO END OF DORSAL. (Plate VI, *l*). *Relative Growth.* Length to end of dorsal decreases relatively with increasing LS, $k_1$ being 1·22, and $m$ 0·88. *Sexual Variation.* Graph shows a well-marked and consistent excess of female over male measurements of an average amount of about 5 per cent. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 2·21 (2·13), min. 1·81 (1·82), mean 2·00 (1·95), median 2·02 (1·94), standard deviation 0·084 (0·080), coefficient of variability 4·2 (4·1). *Remarks.* This is a derived measurement: difficulties in the accurate measurement of one of the dimensions (base of dorsal) from which it is calculated have already been noted.

*(xiii)* LENGTH TO LEVEL OF MAXIMUM GIRTH. (Plate VI, *m*). *Relative Growth.* The level at which maximum girth occurs is decidedly more anterior in smaller individuals, $k_1$ being 1·09, and $m$ 0·78. *Sexual Variation.* Graph shows measurements for females exceeding those for males, the excess ranging from about 2 to about 22 per cent, and averaging about 12 per cent, the most marked divergence occurring in the standard length region occupied by groups B, C, E*b*. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 3·82 (3·54), min. 3·06 (2·45), mean 3·46 (3·19), median 3·40 (3·28), standard deviation 0·281 (0·354), coefficient of variability 8·1 (11·1). *Remarks.* The length to level of maximum girth is roughly equal to the maximum semi-girth of the animal.

*(xiv)* LENGTH FROM CAUDAL NOTCH TO LEVEL OF POSTERIOR MARGIN OF FLUKES. (Plate VI, *n*). This dimension, representing the difference between total length (between parallels) and standard length, decreases relatively with increasing LS, $k_1$ being 0·16, and $m$ 0·12. *Sexual Variation.* The slight female superiority in dimensions shown by the graph is probably not significant. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 70·00 (61·86), min. 27·18 (21·73), mean 49·25 (40·10), median 54·67 (39·38), standard deviation 13·73 (12·37), coefficient of variability 27·9 (38·8). *Remarks.* As might be anticipated, this dimension (the measurement of which is not susceptible of a high degree of accuracy) undergoes very little actual increase in size, and is proportionally much larger in juvenile than in adult individuals, the rate of axial growth in this region being only about one-eight of that of the animal as a whole.

*(xv)* LENGTH TO BLOWHOLE. (Plate VI, *o*). *Relative Growth.* Length to blowhole decreases relatively with increasing LS, $k_1$ being 0·77, and $m$ 0·56. *Sexual Variation.* No appreciable difference between sexes. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 13·09 (12·21), min. 8·03 (7·61), mean 10·90 (9·98), median 11·66 (10·14), standard deviation 2·340 (1·242), coefficient of variability 22·3 (12·5). *Remarks.* As might be anticipated, dimensions such as this and *p*, *q*, *r*, *s*, below, all of which relate to the skull, are already relatively large at birth, and do not increase, with advancing age, at a rate anything like comparable with the rate of increase in general length of the animal.

*(xvi)* OBLIQUE LENGTH OF MOUTH CLEFT. (Plate VI, *p*). *Relative Growth.* Oblique length of mouth cleft decreases with increasing LS, $k_1$ being 0·60, and *m* 0·43. *Sexual Variation.* Values for the sexes are so close that they have been pooled in the diagram to yield a single curve. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 15·57 (14·12), min. 9·96 (10·15), mean 13·30 (12·03), median 14·20 (11·89), standard deviation 2·342 (1·269), coefficient of variability 17·6 (13·3). *Remarks.* The method of taking this measurement has been noted above under CONVENTIONS, where a factor for its approximate conversion into direct length between parallels will be found.

*(xvii)* INTEROCULAR DISTANCE. (Plate VI, *q*). *Relative Growth.* Interocular distance decreases relatively with increasing LS, $k_1$ being 0·66, and *m* 0·47. *Sexual Variation.* From the graph, male measurements consistently exceed female measurements, the excess varying from about 7 to about 13 per cent, and averaging about 12 per cent. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 6·40 (6·36), min. 4·15 (4·72), mean 5·43 (5·42), median 5·61 (5·40), standard deviation 0·876 (0·643), coefficient of variability 16·1 (9·8). *Remarks.* Interocular distance, measured along curve of head, averages more than twice length from most advanced point on head to eye, this large value affording a noteworthy indication of the swollen character of the head in this species.

*(xviii)* DIAMETER OF EYE. (Plate VI, *r*). *Relative Growth.* Diameter of eye decreases relatively with increasing LS, $k_1$ being 0·46, and *m* 0·33. *Sexual Variation.* Values for the sexes are so close that they have been pooled in the diagram to yield a single curve. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 155·14 (133·30), min. 82·50 (83·03), mean 128·07 (116·38), median 139·95 (124·97), standard deviation 29·62 (17·70), coefficient of variability 23·1 (15·2). *Remarks.* This dimension is rather small for comparison with the general length of the animal and is better compared with some smaller dimension, such as length to eye: nevertheless, it yields in the present diagram a good, nearly linear curve, the most noteworthy feature of which is its very small slope, indicative of the reaching early in life of an absolute size that suffers very little increment with advancing age. The value of 0·33 for *m* is the smallest among the dimensions here considered.

*(xix)* GONIDIAL ANGLE TO EYE. (Plate VI, *s*). Gonidial angle to eye decreases relatively with increasing LS, $k_1$ being 0·61, and *m* 0·44. *Sexual Variation.* Values for the sexes are so close that they have been pooled in the diagram to yield a single curve. *Individual Variation.* Statistics of the ratio dimension in LS, as before: max. 53·33 (49·88), min. 32·66 (34·25), mean 46·60 (42·15), median 48·39 (42·58), standard deviation 7·967 (5·158), coefficient of variability 17·09 (12·24). *Remarks.* The dimension varies, with increasing LS, from about two and a half to about three times horizontal diameter of eye.

## SOME SMALLER BODY RATIOS

In the preceding section we have considered nineteen body ratios in which one term of the ratio has been throughout standard length. Some of the smaller dimensions are, however, more profitably investigated in relation to dimensions other than LS, partly on account of their small size, which results under the former treatment in unduly large values, and partly on account of the conventional citation of, and the natural morphological interest attached to, ratios of the type of diameter of eye in length to eye, length (or height) of fin in width (or base) of fin, and so on.

Table III on p. 26 gives some statistics of eighteen such smaller body ratios in which LS does not appear as one term. Values for males and females are presented in separate sections in the table.

Two problems arising from these data—*(a)* what correlation, if any, these ratios exhibit with the general size of the animal, *(b)* what differences, if any, characterize the values of the ratios in the two sexes—are discussed in the next section.

## Smaller Body Ratios in relation to Standard Length

It is of interest to examine the body ratios specified in Table III (p. 26) in regard to correlation with standard length, and in regard to the presence or absence of significant differences between the sexes.

*(a) Standard Length Correlation.* Since any variations in magnitude of the body ratios that do occur at differing body lengths are of the same sense (correlation either positive or negative) in the sexes, and since sexual differences in magnitude, where present, are not in general of a high order, we may conveniently pool male and female values.

The correlation coefficient, $r$, has been calculated by Spearman's rank method, using the formula $r = 1 - \frac{6 \Sigma (d^2)}{n (n^2 - 1)}$, where $d$ is the difference in rank, and $n$ the number of pairs (20).

The 18 body ratios are arranged in descending order of value of $r$, the coefficient of their correlation with LS, thus. Direct correlation ($r$ positive): *(i)* length to eye in length to blowhole ($r$ = 1·0), *(ii)* length of mouth in length to blowhole (0·92), *(iii)* length to eye in length to vent (0·76), *(iv)* length to dorsal in length to vent (0·76), *(v)* length to pectoral in length to vent (0·71), *(vi)* length to level of maximum girth in length to vent (0·67), *(vii)* height of dorsal in length to dorsal (0·65), *(viii)* length of mouth in length to pectoral (0·63), *(ix)* breadth of pectoral in length of pectoral (0·51), *(x)* gonidial angle to eye in interocular distance (0·38), *(xi)* diameter of eye in length to eye (0·36), *(xii)* diameter of eye in length of mouth (0·29), *(xiii)* length to blowhole in length to pectoral (0·28), *(xiv)* height of dorsal in base of dorsal (0·24), *(xv)* length to level of maximum girth in maximum girth (0·18), *(xvi)* length to eye in interocular distance (0·11). Inverse correlation ($r$ negative): height of dorsal in length to eye ($r$ = 0·72), gonidial angle to eye in length of mouth (0·09).

Fisher (1936) has shown that for small samples the distribution of $r$ is not sufficiently close to normality to justify the use of a standard error or a probable error to test its significance, and has developed a more accurate method, based on the distribution of $t$. For a correlation coefficient: $t = \frac{r \sqrt{n}}{\sqrt{1-n^2}}$, when $n$ = the number of degrees of freedom available for estimating the correlation coefficient. At levels of probability of 0·01, 0·02, 0·05, the values of $t$ (18 degrees of freedom) are 2·88, 2·55, 2·10, respectively. From Fisher's formula values of $r$ that will give significances in the present sample of one, two, five in a hundred, respectively, are 0·56, 0·51, 0·44. Hence, of the positive correlations enumerated above, nos *(i)-(viii)* are significant at the first level of probability, and no. *(ix)* at the second level of probability; while nos *(x)-(xvi)* are well below a significance of one in twenty. As regards the two negative correlations, the first, height of dorsal in length to eye, is clearly significant, the second, gonidial angle to eye in length of mouth, clearly non-significant.

*(b) Variation with Sex.* Tests for the significance of differences between means yield the following results. A value of $t$ giving a probability of independence of between 0·05 ($t = 2·10$) and 0·10 ($t = 1·73$) is found for gonidial angle to eye in interocular distanee ($t = 1·99$), gonidial angle to eye in length of mouth (1·90), length of mouth in length to pectoral (1·84); between 0·10 ($t = 1·73$) and 0·50 ($t = 0·688$) for length to level of maximum girth in length to vent (1·72), height of dorsal in length to dorsal (1·44), diameter of eye in length to eye (1·35), length to blowhole in length to pectoral (1·19), breadth of pectoral in length of pectoral (1·05), length to level of maximum girth in maximum girth (0·78), length to eye in interocular distance (0·71), length to dorsal in length to vent (0·70): the remaining ratios have a $t$ value of less than 0·69.

While it is impracticable to interpret with any great degree of certainty significances of differences of means of this order of magnitude, the above results are certainly suggestive of probable differences in proportion between the sexes in the anterior portion of the head region.

Graphical analysis of LS correlation and sex differentiation is conveniently made by consideration of length-classes, rather than of values for individuals, the former method of treatment having the additional advantage, from the point of view of the present survey, of falling into line with the procedure adopted in the examination of dimensions considered as direct functions of LS.

Group-means for the eighteen ratios specified in Table III have accordingly been calculated, and in Plates VII and VIII the means have been plotted against group-means of LS for the seven length-classes specified in Table II. Where curves for the sexes are readily separable visually on the scale adopted, the female graph is shown by dotted line, the male graph by solid line: pooled values for the sexes are shown by dots and dashes.

An examination of the graph shows (over comparable ranges of LS) consistent differences, of varying magnitude, between the male and female graphs in the case of the following ratios plotted against LS: length to pectoral in length to vent (females larger), length to eye in length to blowhole (females larger), diameter of eye in length to eye (females smaller), length of mouth in length to pectoral (females larger), gonidial angle to eye in interocular distance (females larger), length to level of maximum girth in length to vent (females smaller).

In general these differences are slight, being most marked in the case of gonidial angle to eye in interocular distance.

A comparison of the results of graphing group-means with differences of means calculated direct from the ten individuals of either sex metrically examined suggests rather strongly that distinct differences of proportion between the sexes probably exist in the case of at least the four following ratios: gonidial angle to eye in interocular distance, length of mouth in length to pectoral, length to level of maximum girth in maximum girth, diameter of eye in length to eye—the numerical values of the first two ratios being larger, those of the second two smaller, in females than in males.

## Table III

Globicephalus melas (Traill, 1809): Some Body Ratios in relation to Standard Length

| Ratio | Ratio in standard length | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Males | | | | | | Females | | | | | |
| | Max. | Min. | Mean | Median | Standard Deviation | Coefficient of Variability | Max. | Min. | Mean | Median | Standard Deviation | Coefficient of Variability |
| Height of dorsal in length to dorsal | 5·57 | 4·01 | 4·73 | 4·67 | 0·5910 | 12·5 | 5·77 | 4·35 | 5·05 | 5·04 | 0·3770 | 7·5 |
| Height of dorsal in base of dorsal | 3·45 | 1·78 | 2·78 | 2·83 | 0·4552 | 16·3 | 3·28 | 2·44 | 2·79 | 2·73 | 0·2154 | 7·8 |
| Height of dorsal in length to eye | 1·69 | 0·98 | 1·28 | 1·19 | 0·2439 | 19·1 | 1·42 | 1·02 | 1·26 | 1·26 | 0·1204 | 9·6 |
| Length to dorsal in length to vent | 2·16 | 1·64 | 1·95 | 2·00 | 0·0528 | 2·7 | 2·04 | 1·76 | 1·88 | 1·88 | 0·0878 | 4·6 |
| Breadth of pectoral in length of pectoral | 4·06 | 3·46 | 3·74 | 3·66 | 0·2307 | 6·2 | 3·96 | 3·11 | 3·63 | 3·61 | 0·2519 | 6·9 |
| Length to pectoral in length to vent | 4·59 | 3·17 | 4·01 | 4·24 | 0·5405 | 13·5 | 5·39 | 3·44 | 4·06 | 4·01 | 0·5096 | 12·6 |
| Length to eye in length to blowhole | 1·22 | 1·07 | 1·12 | 1·11 | 0·0529 | 4·7 | 1·27 | 1·10 | 1·19 | 1·19 | 0·0576 | 0·4 |
| Length to eye in interocular distance | 2·56 | 2·04 | 2·22 | 2·17 | 0·1792 | 8·1 | 2·38 | 1·84 | 2·17 | 2·22 | 0·1490 | 6·9 |
| Length to eye in length to vent | 9·22 | 5·70 | 7·39 | 7·66 | 1·1586 | 15·7 | 8·15 | 5·88 | 7·30 | 7·38 | 0·7348 | 10·1 |
| Diameter of eye in length to eye | 12·11 | 7·68 | 10·50 | 10·83 | 1·2699 | 12·1 | 11·17 | 8·35 | 9·90 | 9·98 | 0·9173 | 9·3 |
| Diameter of eye in length of mouth | 10·16 | 8·28 | 9·58 | 9·53 | 0·4301 | 4·5 | 11·17 | 8·18 | 9·64 | 9·71 | 0·9305 | 9·7 |
| Length of mouth in length to blowhole | 1·33 | 0·99 | 1·22 | 1·24 | 0·0333 | 2·5 | 1·38 | 1·07 | 1·22 | 1·27 | 0·1040 | 8·5 |
| Length of mouth in length to pectoral | 2·17 | 1·83 | 2·02 | 2·04 | 0·1123 | 5·6 | 2·12 | 1·66 | 1·92 | 1·91 | 0·1241 | 6·4 |
| Gonidial angle to eye in length of mouth | 3·68 | 3·20 | 3·44 | 3·46 | 0·2118 | 6·2 | 4·00 | 3·14 | 3·51 | 3·49 | 0·3190 | 9·1 |
| Gonidial angle to eye in interocular distance | 9·62 | 7·68 | 8·40 | 8·37 | 0·6287 | 7·5 | 9·29 | 7·10 | 7·78 | 7·50 | 0·7513 | 9·7 |
| Length to blowhole in length to pectoral | 1·91 | 1·56 | 1·67 | 1·61 | 0·1174 | 7·0 | 1·75 | 1·31 | 1·60 | 1·60 | 0·1356 | 8·5 |
| Length to level of max. girth in max. girth | 1·97 | 1·77 | 1·84 | 1·81 | 0·0775 | 4·2 | 2·10 | 1·52 | 1·80 | 1·79 | 0·1706 | 9·5 |
| Length to level of max. girth in length to vent | 2·32 | 1·81 | 2·12 | 2·08 | 0·1366 | 6·5 | 2·20 | 1·52 | 1·99 | 2·04 | 0·1884 | 9·5 |

## AXIAL GROWTH REGIONS

Pearson (1936, p. 190), discussing the present data and the dimensions of a female foetus of LS 102 (obtained from a specimen of the present series), has observed ' A comparison of the foetal with the adult measurements shows that in the younger stages the anterior half of the body is proportionally larger than in the older stages. This is shown, for example [table of measurements expressed as percentages of total length provided], in the comparisons of the length from the snout to vent and in the length of the flippers '.

The gradual relative displacement cephalad of structures anterior to the vent is by no means confined to that section of the life-history represented by the extremes of, at one end, a foetus of standard length of the order of one metre, and, at the other end, juvenile specimens of the smallest size included in the present sample. It continues throughout the whole range of growth covered by the individuals here examined.

If we examine a group of morphological landmarks arranged in linear series along the anteroposterior body axis in advance of vent, we observe a marked inverse correlation between length to landmark and standard length. Data relating to such a series are set out in Table IV (p. 30), in which comparisons are instituted between the minimum and maximum length classes of both sexes. The dimensions selected for examination here are: length to eye, to blowhole, to origin of pectoral, to level of maximum girth (though less directly related to the skeletal framework than the other terms of the series, this dimension is here included in view of its interest as a factor in general body conformation), to origin of dorsal, to termination of dorsal, to vent.

From Table IV (p. 30) it will be seen that, in passing from the minimum to the maximum length-class, the postanal portion of the animal increases in males (over a range of LS of 330·6) from 34·2 to 42·1 per cent, and in females (over a range in LS about half as wide, namely, 166·0) from 32·3 to 39·3 per cent.

Posterior to the vent the only axial morphological landmarks of note are the caudal notch and the (less important) posterior border of flukes. The small region between these two points has already been shown (section on SOME DIMENSIONS IN RELATION TO STANDARD LENGTH, subsection *(xiv)*, above) to suffer considerable relative decrease with increasing length of animal ($m = 0{\cdot}6$) : it is highly probable, on the other hand, that whole region lying between the vent and the caudal notch increases as a direct function of age.

The variation in proportion at the selected points on the main axis of the body here discussed is deemed sufficiently noteworthy to merit diagrammatic representation; and Plate IX, fig. 1 has been provided to illustrate this striking feature of the growth of this species.

## AXIAL GROWTH GRADIENT: GROWTH POTENTIAL

While the selected points in advance of vent considered in the preceding section agree in exhibiting a rate of growth lower than that of the animal as a whole (standard length), it is unlikely, in view of the character of axial growth gradients in general, that the growth potential should remain constant over the whole preanal region. The problem can conveniently be examined—with an extension of the data to include also the postanal portion of the animal—by a consideration of the rates of relative growth exhibited in the following regions: most advanced point of head to anterior margin of eye, anterior margin of eye to origin of pectoral, origin of pectoral to origin of dorsal, origin of dorsal to vent, vent to caudal notch. The small region between caudal notch and level of posterior margin of flukes (the latter point is measureable with, at best, indifferent accuracy) is not considered, since its inclusion would in some cases involve the handling of a negative value for $k_1$, the dimension being at times absolutely greater in the lower than in the higher length-class, a circumstance probably partly accounted for by individual variation, partly also perhaps by an actual alteration in configuration of the region with advancing age.

On comparing the 10 individuals above, with the 10 individuals below, the median standard length (this arbitrary division, as it happens, conveniently results in the inclusion in the former category of the maximum female length-class, F*b*, and the maximum male length-class, G; with the relegation of all other length-classes, male and female, to the latter category), we obtain for the growth coefficient, $k_1$, of the regions specified the following values: 0·29, 0·34, 0·50, 0·69, 0·64. The plotting of these values as ordinates, spaced at equal arbitrary intervals, yields a curve representing the distribution along the axial line of the animal of growth potential. The curve derived from the present data is shown in Plate IX, fig. 2. It will be seen that the growth gradient increases steadily up to the last region but one (interval between dorsal origin and vent), thereafter descending slightly in the interval between vent and caudal notch: hence, the growth centre (highest point of gradient) occurs at ordinate no. 4, the most rapid relative growth being met with between dorsal origin and vent, and the mean rate of relative growth caudad of this point being much greater than cephalad of it. To obtain a somewhat clearer picture of the relative axial distribution of higher and lower rates of growth the ordinates 1-5, spaced equidistantly in the figure, could be visualized as being set at intervals, from left to right, of 1, 2, 4, 2 units apart, these values approximately representing the relative lengths of the body regions considered.

An examination of the values of $k_1$ for the specified regions calculated separately for males and females reveals a curious divergence between the sexes, with the maximum value of the curve occurring in males at ordinate no. 4 (as in the general population), and in females at ordinate no. 5.

The male curve, shown by solid line (Plate IX, fig. 2), is based on a comparison of the largest six specimens (length-class G) with the remaining four males, $k_1$ being 0·12, 0·17, 0·75, 1·22, 0·87. The female curve, shown by broken line (Plate IX, fig. 2), is based on a comparison of the largest four specimens (length-class F*b*) with the remaining six females, $k_1$ being 0·12, 0·15, 0·30, 0·24, 0·41.

The suggestion afforded by these graphs of a more cephalad location of the growth centre in males than in females receives some support from an examination of curves based on other groups of individuals (*e.g.*, smallest female individual compared with largest individual, and so on).

## General Form

The Pilot Whale is sometimes described as having no 'beak', sometimes as being provided with a short 'beak'. The latter description is, on the whole, the better one, since, although there is certainly no long, more or less slender beak of the extreme delphinoid type, the dorsal profile of the much-swollen fore part of the head commonly becomes distinctly concave above the level of the mouth, so that the tip of the upper jaw, though not necessarily the most anterior point of the head as a whole, comes to lie noticeably in advance of the cephalic profile immediately above it, the net result being the formation of what is naturally thought of, and may appropriately enough be termed, a short 'beak'. Some evidence has already been adduced that would suggest the expansion of the head in the region of the 'forehead' is greater in males than in females.

Matters relating to the proportional development of various body regions and structures in different sexes and at different ages having already been discussed in some detail, little remains to be noted here as regards general form. The following few comments of a miscellaneous character may, however, conveniently be included in the present section.

The dorsal fin has a long curved anterior margin: though sloping backwards, the fin was, in the specimens examined, in general, somewhat more erect, and rather more acutely pointed, than shown in some illustrations of this species: the lapse of the posterior margin caudad into the dorsal body profile is very gradual.

The long, slender pectorals originate low down on the body: the anterior margin of the fin is characteristically an unbroken curve, gently concave distally, the maximum width occurring in the neighbourhood of the basal one-third of the fin.

The flukes are fairly pointed, and have a decidedly sinuous posterior margin, rather sharply re-entering at the middle of the tail-fin to constitute the caudal notch.

The line of the mouth-cleft is moderately oblique; much less so, however, in the specimens examined, than it is sometimes pictured. The teeth occupy the anterior part of the mouth only, the total length of the tooth-line of the lower jaw being between one-third and one-fourth of the length of the mandible.

A point of interest is the retention, not uncommon in Cetacea, of the umbilical scar to an advanced age. Even among the largest individuals of the school, it was commonly noticeable to an observer standing some distance away from the animal, though its conspicuousness was no doubt somewhat enhanced by the almost universal presence at this point of some element of differentiation in the coloration of the light midventral stripe, a circumstance dealt with more fully in the next section.

## COLORATION

The coloration of this species is usually given as black—*e.g.*, 'jetty-black', 'black, smooth and shining like oiled silk'—all over, with a small amount of white on the lower surface; occasionally as wholly black. The colours of a female and of a male are described in some detail below, and these observations are followed by some general notes on coloration among the series of specimens examined.

### I. COLORATION OF A FEMALE OF LS 380 (SPECIMEN NO. 7)

*(a) Lateral Aspect.* (Plate X, fig. 1.) An irregular, subrectangular scapular patch of dark elephant colour, about thrice as long as high (its length about two-thirds length of mouth-cleft between parallels), beginning about one-fourth length of mouth-cleft behind angle of mouth, and lying about midway between level of angle of mouth and dorsal profile. Whole of rest of lateral aspect black, the colour not a flat black, but, in a greater or lesser degree in various regions, shiny.

*(b) Dorsal Aspect.* (Plate X, fig. 2.) A large somewhat pyriform region of dark elephant on the mid-dorsal line, beginning immediately behind the base

## TABLE IV

GLOBICEPHALUS MELAS (TRAILL, 1809): DISPLACEMENT CEPHALAD OF MORPHOLOGICAL LANDMARKS ANTERIOR TO VENT

| SEX | LENGTH-CLASS | LENGTH (AS THOUSANDTHS OF STANDARD LENGTH) TO MORPHOLOGICAL LANDMARK SPECIFIED | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Eye | Blowhole | Origin of Pectoral | Level of Maximum Girth | Origin of Dorsal | Termination of Dorsal | Vent |
| MALE | Minimum Length—Class A | 105 | 112 | 195 | 321 | 369 | 530 | 658 |
| | Maximum Length—Class G | 78 | 83 | 139 | 281 | 296 | 493 | 579 |
| FEMALE | Minimum Length—Class B | 115 | 131 | 197 | 354 | 372 | 531 | 677 |
| | Maximum Length—Class F*b* | 79 | 93 | 150 | 284 | 322 | 512 | 607 |

of the dorsal fin, and extending caudad for a distance greater than the length of the base of the fin, the width of the patch about half its length. Rest of dorsal aspect black.

*(c) Dorsal Fin.* Wholly black.

*(d) Ventral Aspect.* (Plate XI.) The ventral surface is in general black, with a median whitish or greyish region extending from about level of angle of mouth to a short distance behind urinogenital groove, and with two elongate patches of medium elephant flanking the medial light-coloured streak along part of its posterior one-third. The remainder of the lower surface is black.

In this specimen, of standard length 380, and with length (between parallels) to angle of mouth, length to origin of flippers, length to vent 23, 62, 236, respectively, and with a maximum girth of 217, occurring 121 behind most advanced point on head, the light ventral marking extends for a total distance of about 225, and has a maximum and minimum width of about 45, 1·8, respectively. It is widest anteriorly, where it expands to touch the bases of the pectorals; runs, as a narrow strip, to well beyond the level of the tips of the pectorals; then broadens out again, though only to about half its greatest width anteriorly, to embrace the umbilicus and the urinogenital groove, behind which latter it ceases rather abruptly. On the left side of the animal the light-coloured region reaches to within 26·5 of level of tip of mandible; on the right side, it does not extend quite so far. Near the middle of its mainly convex anterior margin, a medial notch is produced in it by the presence of a spur of the body-black: the tip of this spur is 26·5 distant from tip of mandible. On the throat, the light area has a width at its middle of about 31: behind this it continues backwards and somewhat outwards to form a narrow band that meets the pectoral base in the latter's outer one-third: the width of this band may vary on the two sides of the same individual: on the left side of the present specimen it measures 6·5. The inner margin of the band extends from pectoral base forwards and inwards for some short distance in a smooth curve, and then swings round, in a very irregularly denticulated arc, to form the outer margin of the narrow medial strip that begins a little in advance of level of pectoral origin. At about level of hinder end of pectoral base the medial strip is 1·8 wide (its minimum width), at level of end of pectoral 3 wide: thereafter it begins to broaden, its widths at level of umbilicus, at just in advance of urinogenital opening, and at level of mammary slits being, respectively, 10, 12, 17 (the last measurement being the maximum width occurring posterior to pectoral base).

The degree of asymmetry of the pattern indicated in the figure closely approximates the state of affairs observed.

The colour of this moderately extensive ventral marking, which is fairly typically developed in the present specimen, varies from almost pure white to medium grey, the disposition of the colours being as follows: throat-patch almost pure white anteriorly, slightly greyish white posteriorly (no sharp line of demarcation); narrow strip caudad to umbilicus light grey to medium grey; umbilicus conspicuously marbled grey and white; from umbilicus to urinogenital groove slightly greyish, not marbled; in vicinity of mammary slits almost pure white.

The patches of medium elephant-colour noted above as flanking part of the medial light region extend, on either side, from about the level of the umbilicus to about the level of the anterior margin of the urinogenital groove: they are widest at the middle, where their combined width somewhat exceeds the width of the light greyish strip separating them.

Apart from the markings just described, the whole of the ventral surface of this individual was black.

The under surface of the pectorals is considered below *(e)*.

*(e) Pectoral Fin.* (Plates X, XI.) Wholly black, about concolorous with body generally, except for a small roughly hemispherical patch of marbled greyish and elephant, occurring at the base on the lower surface. On the right fin the patch is situated near the proximal portion of the preaxial border; on the left fin, where it is rather more extensive, it is carried a little inwards to embrace about one-half of the basal border of the fin.

*(f) Flukes.* Blackish, concolorous with body near them.

*(g) Oral Cavity.* Palate dark slate grey. Tongue (which is crenulated, with about a score of small lobes along each lateral margin) white, flushed faintly pinkish. Floor of mouth white. Lingual surface of jaws jet black. Gums intermediate between gamboge and yellow ochre.

*(h) Eye.* Iris bluish white. Rest of eye dark bluish.

### II. Coloration of a Male of LS 231 (Specimen No. 6)

*(a) Lateral Aspect.* Upper one-third of sides black; below this, dark elephant, becoming progressively lighter ventrally. No scapular smear such as that found in female described above.

*(b) Dorsal Aspect.* Blackish. No medial post-dorsal patch of elephant.

*(c) Dorsal Fin.* Blackish, about concolorous with body near it. (See *(e)*, below).

*(d) Ventral Aspect.* Ground colour of ventral surface dark hide colour. Light-coloured pattern on throat and along midventral line to shortly beyond vent much as in female (no. 6) described above, the chief differences noted being: *(i)* throat-patch relatively a little wider, its anterior margin more symmetrical, less rounded and more truncate (but medial tongue of body-colour present as before, though perhaps a little longer and narrower); *(ii)* 'arms' of light colour extending outwards to touch pectorals wide, embracing most of base of fin.

*(e) Pectoral Fin.* Black, rather darker than dorsal fin and flukes. A fairly extensive patch of mottled elephant basally on lower surface.

*(f) Flukes.* Blackish. (See *(e)*, above.)

*(g) Oral Cavity.* Much as in female described above.

*(h) Eye.* Iris bluish white. Rest of eye dark bluish.

### III. General Observations on Coloration

Observations made on a large number of individuals yielded the following data.

*(a) Ground Colour.* In general black, becoming in some cases elephant or hide brown on the lower lateral and the ventral surfaces: this lightening of ground colour is not uncommon in small individuals (*cf.* no. 6, described above), but occurs only occasionally, and then to a much less marked degree, among adults.

*(b) Dorsal Fin.* Almost invariably black. In a few small individuals somewhat lighter. Very occasionally marked, as if smeared, with elephant basally.

*(c) Pectoral Fin.* Usually black, the colour often rather more intense than that of the body nearby. Proximal portion of inner surface frequently, perhaps more often than not, mottled elephant, or hide brown or marbled grey (*cf.* no. 7: Plate XI). In one individual virtually the whole under-surface of the flipper was a fairly light grey, marbled and streaked with darker grey and greyish brown.

*(d) Flukes.* Almost invariably black. Somewhat lighter in a few specimens.

*(e) Shoulder Marking.* In perhaps the majority of cases there was present, near the shoulder, a region of dark elephant, with boundaries moderately sharply marked off from the prevailing body colour. The colour in this part gave the impression of the black of the body having been partly smeared off, as it were, while the colour was still wet. A somewhat similar effect, with a closely comparable tint, is obtained by thickly washing in an area of white paper with a good black ticketing ink, and then immediately taking up the excess fluid with a scrap of blotting paper. All the available evidence seemed, however, clearly to favour the view that such patches were an integral feature of the colour-pattern, and to be opposed to any explanation based on the effects of friction.

*(f) Median Post-Dorsal Patch.* A patch of dark elephant colour lying immediately behind the dorsal fin (*cf.* no. 7: Plate X, fig. 2), similar in general character to, but perhaps rather more clearly delimited than, the scapular patch, was less constantly present than the latter marking.

*(g) Ventral Marking.* The light-coloured pattern on the ventral surface, forming the most striking feature of the coloration, was constantly present, though sometimes less conspicuous in very young than in more mature individuals. In configuration it conformed closely, in the great majority of cases, to the general type of outline shown in Plate XI, the most striking variation being an occasional marked expansion near the level of the extremities of the adpressed flippers. The prevailing colour was near-white marbled with greyish, or greyish (about dove grey) marbled with darker grey; or near-white, or dove grey, unmarbled. The light-coloured pattern was never uniform in tint throughout, not infrequently weakening (*i.e.*, approximating more closely to dark ground colour) near the middle of the narrow midventral stripe midway between level of pectoral base and umbilicus (near point of minimum width in specimen shown in Plate XI), but of about a hundred individuals examined only two were observed in which the stripe suffered actual interruption. The nearest approach to white occurred either just in advance of mammary slits (*cf.* no. 7: Plate XI), or in the anterior portion of the broad patch on the throat, of which region the anterior median notch was almost invariably a conspicuous and sharply defined feature. The umbilical scar was usually coloured or marked somewhat differently from the immediately adjacent region—*e.g.*, being marbled greyish, in the midst of uniform grey, or whitish grey; most commonly marbled to a greater or lesser degree.

*(h) Oral Cavity.* The coloration of the interior of the mouth appeared to vary considerably in accordance with the length of time the animal had been dead. An examination of half a dozen living specimens yielded the following results. Palate dark slate grey, tending to become a little lighter laterally; sometimes vermiculated with light grey, or whitish; usually with two or three large irregular patches (up to about the size of a man's hand) of pink posteriorly. Tongue ranging from faintly pinkish white to grey. Floor of mouth whitish below tongue, becoming greyish laterally. Lingual surface of jaws black. Gums gamboge, yellow ochre, or some closely similar colour.

*(i) Penis.* When resting in its groove in young males, mottled grey and dark brown; when extended and distended in large males, more or less greyish.

*(j) Variation of Coloration with Age.* As noted in *(a)* above, a lightening of the ground colour is to some extent characteristic of juvenile animals, occurring rarely, and then to a much less marked degree, among adults; and, as noted in *(g)*, the light-coloured ventral pattern is upon occasion somewhat less conspicuous in very young individuals.

*(k) Variation of Coloration with Sex.* Careful examination failed to disclose any constant observable difference in coloration between the sexes.

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## PLATE I

SCHOOL OF PILOT WHALES, GLOBICEPHALUS MELAS (TRAILL, 1809), STRANDED AT STANLEY, NORTH WESTERN TASMANIA, OCTOBER, 1935

Fig. 1.—Main mass of whales still on sandspit on which they first became stranded. (Looking eastward from the Green Hills, from below the residence of Mr J. Trethewie, by whom the whales were first seen. Rocky Cape and the Sisters Hills in extreme distance. The township of Stanley lies to the left).

Fig. 2.—Part of the school washed further up on to Tatlow's Beach. (Looking westward. Part of the hedge seen running up hill in background, slightly to right of middle of picture, is included in right foreground of Fig. 1).

Fig. 3.—Portion of the school on Tatlow's Beach. (Looking southward. Extreme end of the Green Hills just entering picture on right).

Fig. 4.—Another view of part of the school on Tatlow's Beach. (Looking further towards the direction of Black River than in Fig. 3).

Fig. 1

Fig. 2

Fig. 3

## Plate II

School of Pilot Whales, *Globicephalus melas* (Traill, 1809), stranded at Stanley, North Western Tasmania, October, 1935

Fig. 1.—Towing a whale into East Inlet Channel, bound for the 'whale cemetery'.

Fig. 2.—Towed ashore by bullocks. (Looking eastward. Portion of The Nut seen in left background).

Fig. 3.—Another view of bullocks at work.

Fig. 4.—A specimen (female?) on Tatlow's Beach. (Looking westward).

Fig. 5.—Another view of individual seen in Fig. 4. (Part of the Green Hills in right background).

Fig. 6.—General view of carcases near site of burial: still on beach.

Fig. 7.—Carcase being dragged behind sand dune. (The Nut in the distance).

Fig. 8.—Whales after being dragged behind sand dunes fringing beach: buried in large trenches near here.

FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5

FIG. 6

FIG. 7

FIG. 8

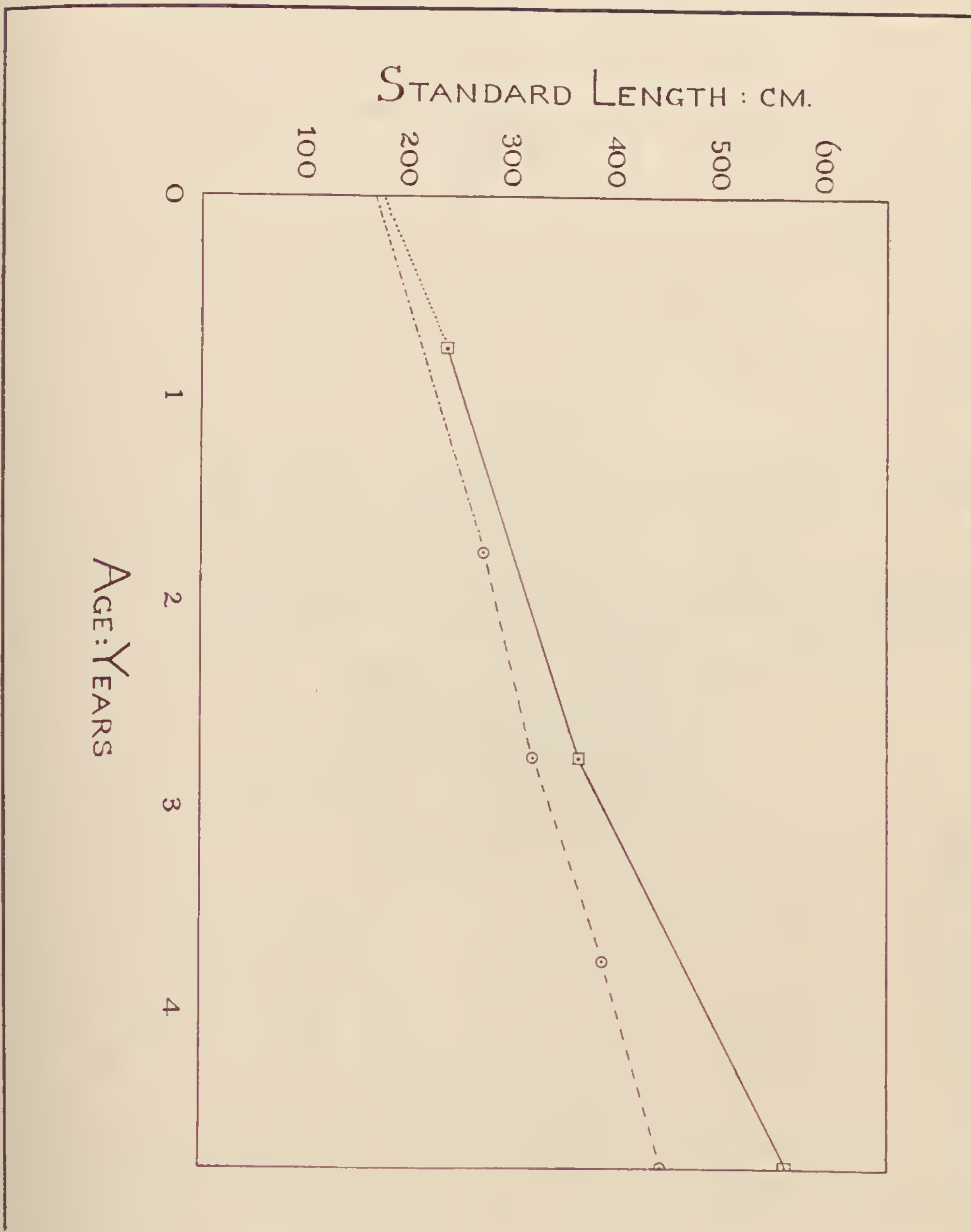
## Plate III

School of Pilot Whales, Globicephalus melas (Traill, 1809), stranded at Stanley, North Western Tasmania, October, 1935

### Year-Classes

Seven length-classes (comprising in all 22 individuals) plotted against a conjectured time-scale. Smallest and largest males examined presumed to be $\frac{2}{3}$-$\frac{3}{4}$ year, $4\frac{2}{3}$-$4\frac{3}{4}$ years old, respectively; smallest and largest females examined presumed to be $1\frac{2}{3}$-$1\frac{3}{4}$ years, $4\frac{2}{3}$-$4\frac{3}{4}$ years old, respectively.

Male curve shown by solid line, its extrapolated portion by line of dots. Female curve shown by line of dashes, its extrapolated portion by line of dots and dashes.


STANDARD LENGTH : CM.
100
200
300
400
500
600
AGE : YEARS
0
1
2
3
4

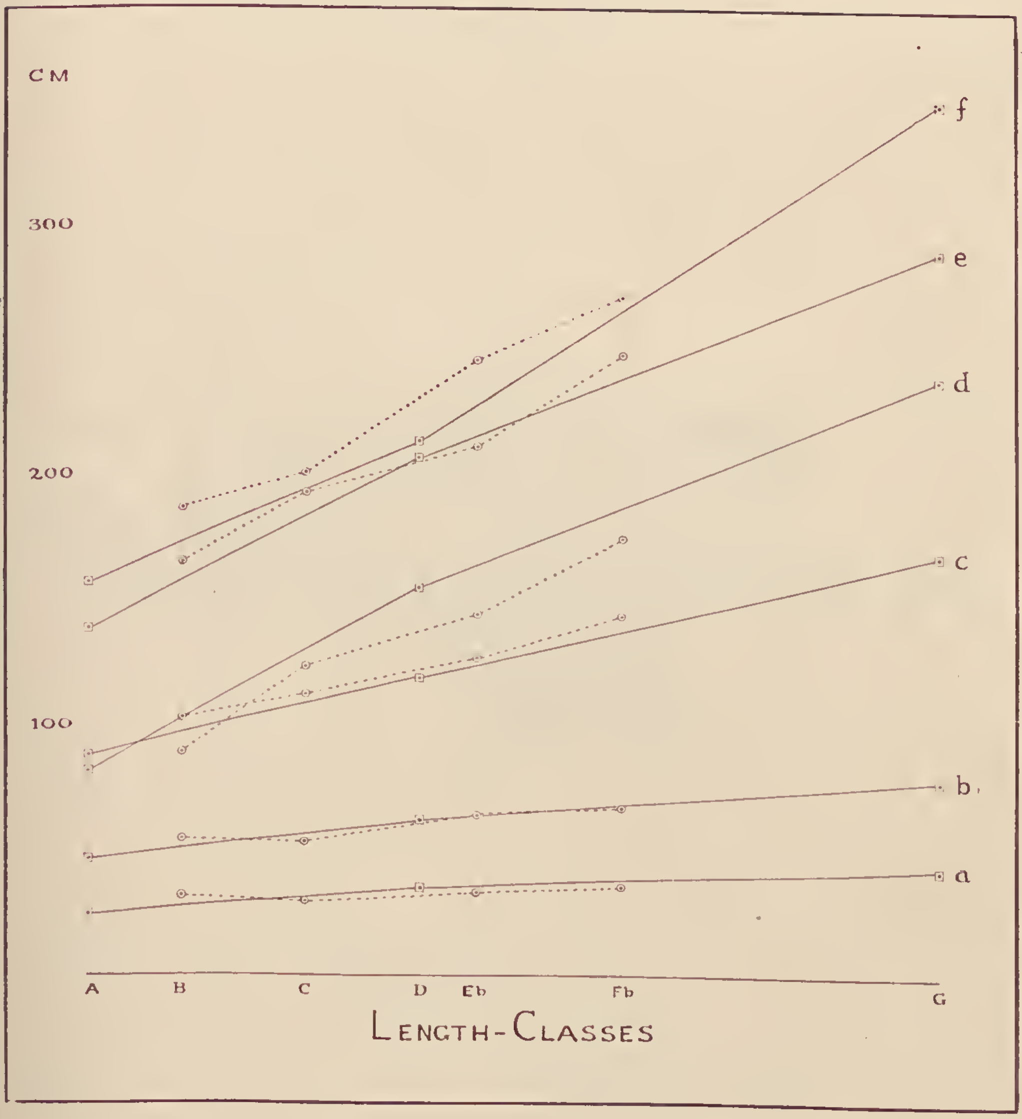
## PLATE IV

SCHOOL OF PILOT WHALES, GLOBICEPHALUS MELAS (TRAILL, 1809), STRANDED AT STANLEY, NORTH WESTERN TASMANIA, OCTOBER, 1935

SOME DIMENSIONS ON STANDARD LENGTH

Six dimensions of seven length-classes (comprising in all 20 individuals) plotted against standard length. Male curve shown by solid line, female curve by line of dashes. Ordinate scale applies to all curves in this plate.

*a.* Length to eye.
*b.* Length to origin of pectoral.
*c.* Length to origin of dorsal.
*d.* Postanal length.
*e.* Maximum girth.
*f.* Length to vent.


CM
300
200
100
f
e
d
c
b
a
A
B
C
D
Eb
Fb
G
LENGTH-CLASSES

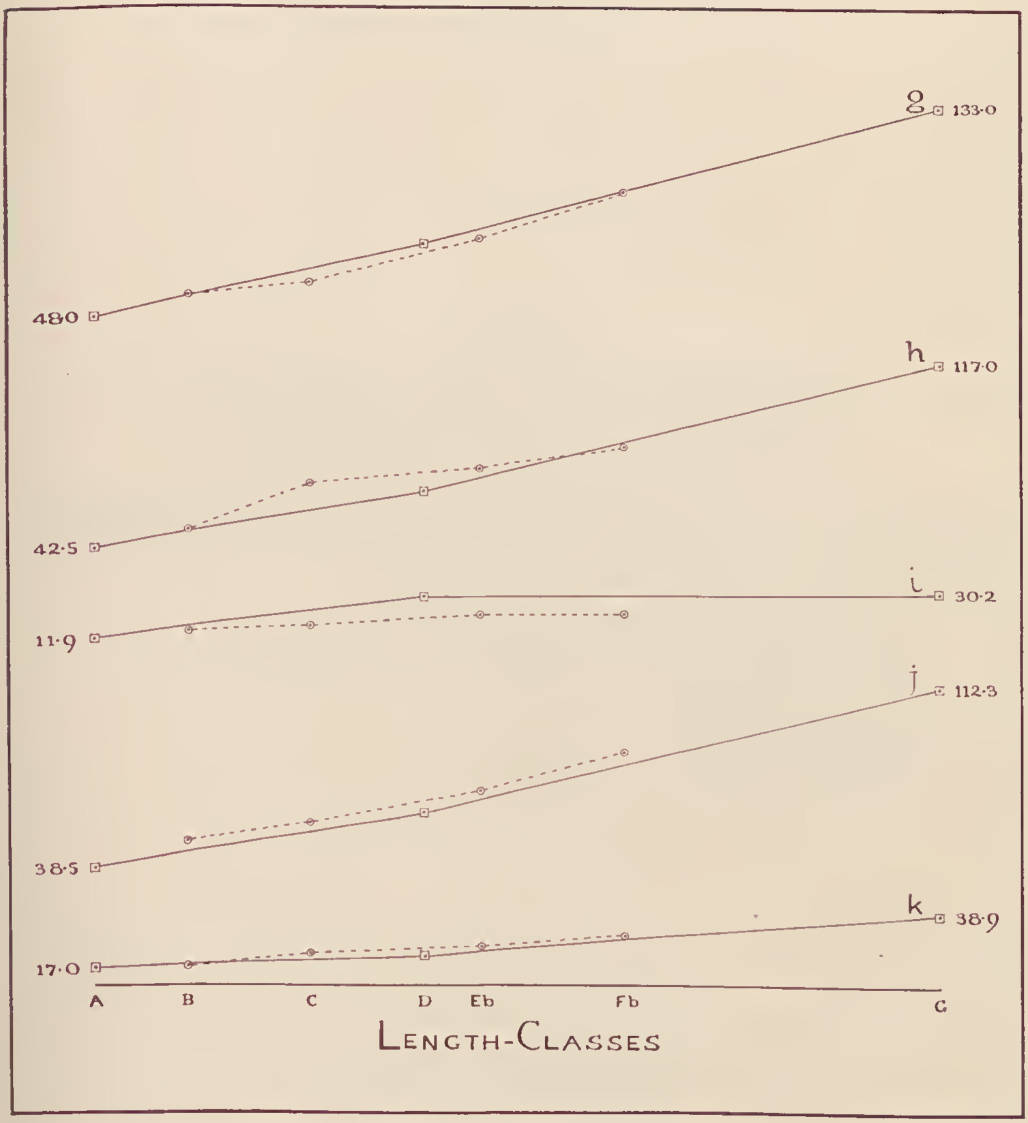
## Plate V

School of Pilot Whales, Globicephalus melas (Traill, 1809), stranded at Stanley, North Western Tasmania, October, 1935

Some Dimensions on Standard Length (Continued)

Five dimensions of seven length-classes (comprising in all 20 individuals) plotted against standard length. Male curve shown by solid line, female curve by line of dashes. A separate ordinate scale is used for each dimension.

*g*. Spread of flukes.
*h*. Length of pectoral.
*i*. Maximum breadth of pectoral.
*j*. Base of dorsal.
*k*. Height of dorsal.


g
133·0
48·0
h
117·0
42·5
i
30·2
11·9
j
112·3
38·5
k
38·9
17·0
A
B
C
D
Eb
Fb
G
Length-Classes

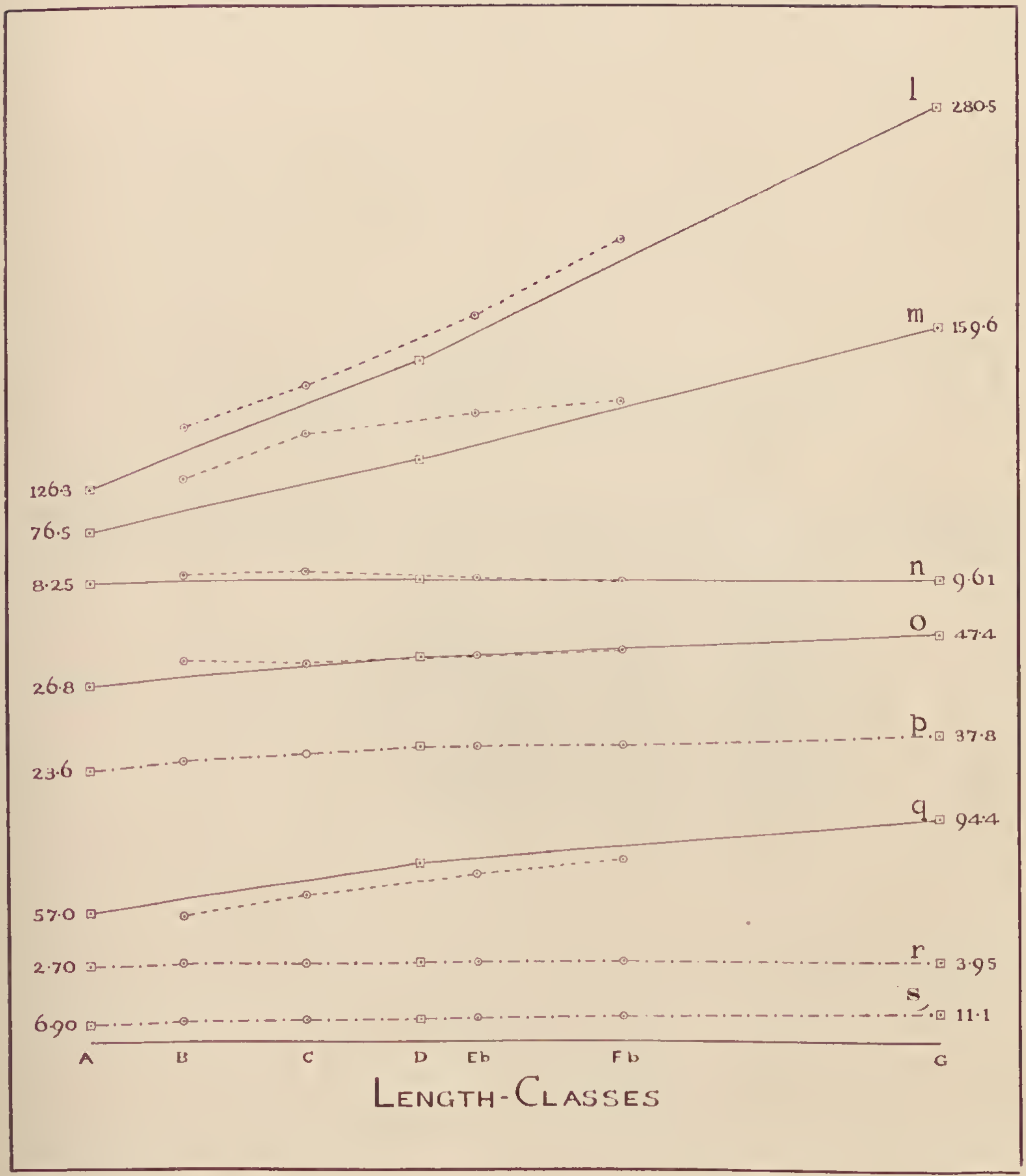
## PLATE VI

SCHOOL OF PILOT WHALES, GLOBICEPHALUS MELAS (TRAILL, 1809), STRANDED AT STANLEY, NORTH WESTERN TASMANIA, OCTOBER, 1935

SOME DIMENSIONS ON STANDARD LENGTH (CONTINUED)

Seven dimensions of seven length-classes (comprising in all 20 individuals) plotted against standard length. Male curve shown by solid line, female curve by line of dashes, pooled curve for both sexes by line of dots and dashes. A separate ordinate scale is used for each dimension.

*l*. Length to end of dorsal.
*m*. Length to level of maximum girth.
*n*. Length from caudal notch to level of posterior margin of flukes.
*o*. Length to blowhole.
*p*. Length of mouth.
*q*. Interocular distance.
*r*. Diameter of eye.


l
280·5
m
159·6
126·3
76·5
8·25
n
9·61
o
47·4
26·8
p
37·8
23·6
q
94·4
57·0
2·70
r
3·95
s
6·90
11·1
A
B
C
D
Eb
Fb
G
LENGTH-CLASSES

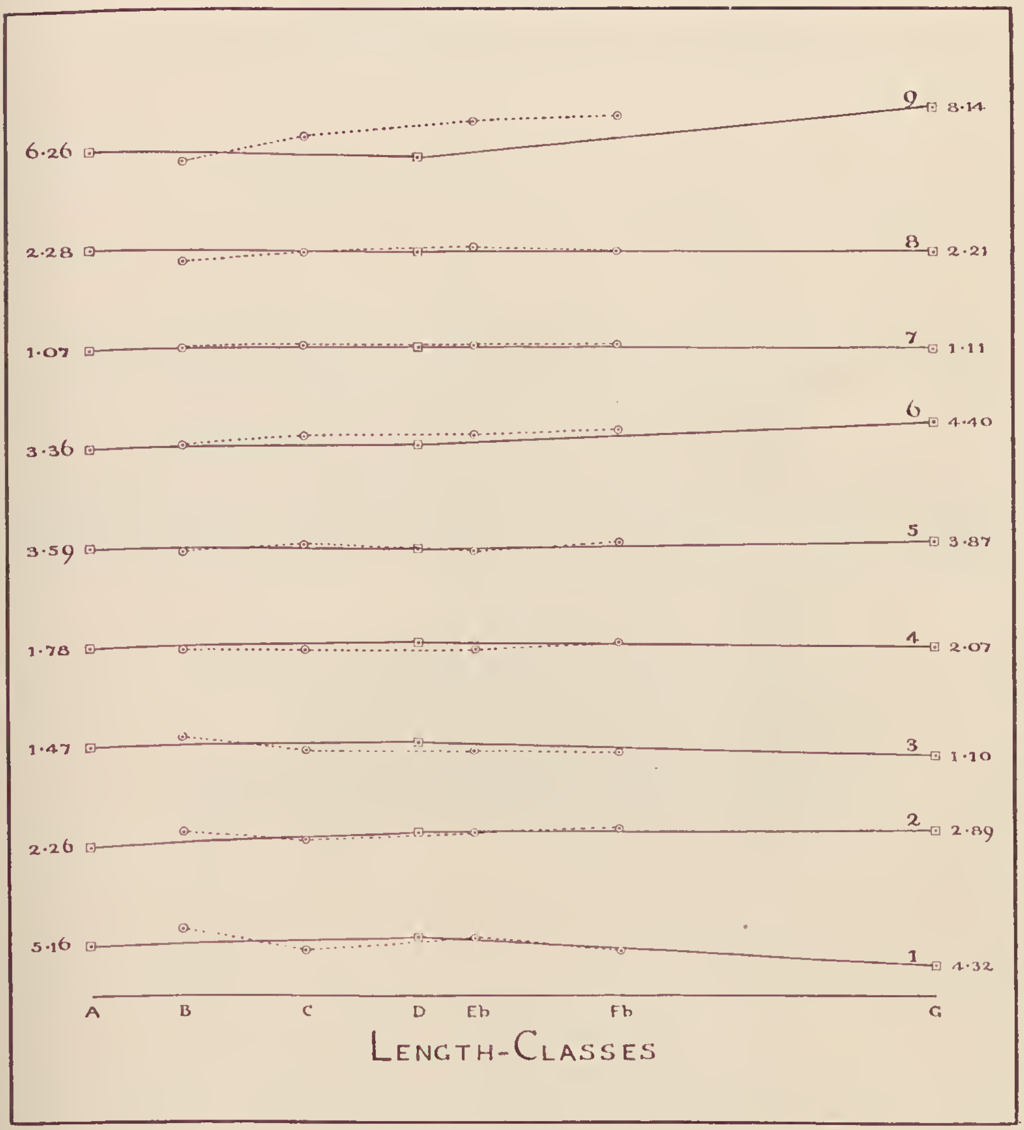
## Plate VII

School of Pilot Whales, *Globicephalus melas* (Traill, 1809), stranded at Stanley, North Western Tasmania, October, 1935

### Some Body Ratios on Standard Length

Nine body ratios of seven length-classes (comprising in all 20 individuals) plotted against standard length. Male curve shown by solid line, female curve by line of dashes. A separate ordinate is used for each body ratio.

1. Height of dorsal in length to dorsal.
2. Height of dorsal in base of dorsal.
3. Height of dorsal in length to eye.
4. Length to origin of dorsal in length to vent.
5. Maximum breadth of pectoral in length of pectoral.
6. Length to pectoral in length to vent.
7. Length to eye in length to blowhole.
8. Length to eye in interocular distance.
9. Length to eye in length to vent.


9
6·26
8·14
8
2·28
2·21
7
1·07
1·11
6
3·36
4·40
5
3·59
3·87
4
1·78
2·07
3
1·47
1·10
2
2·26
2·89
1
5·16
4·32
A
B
C
D
Eb
Fb
G
LENGTH-CLASSES

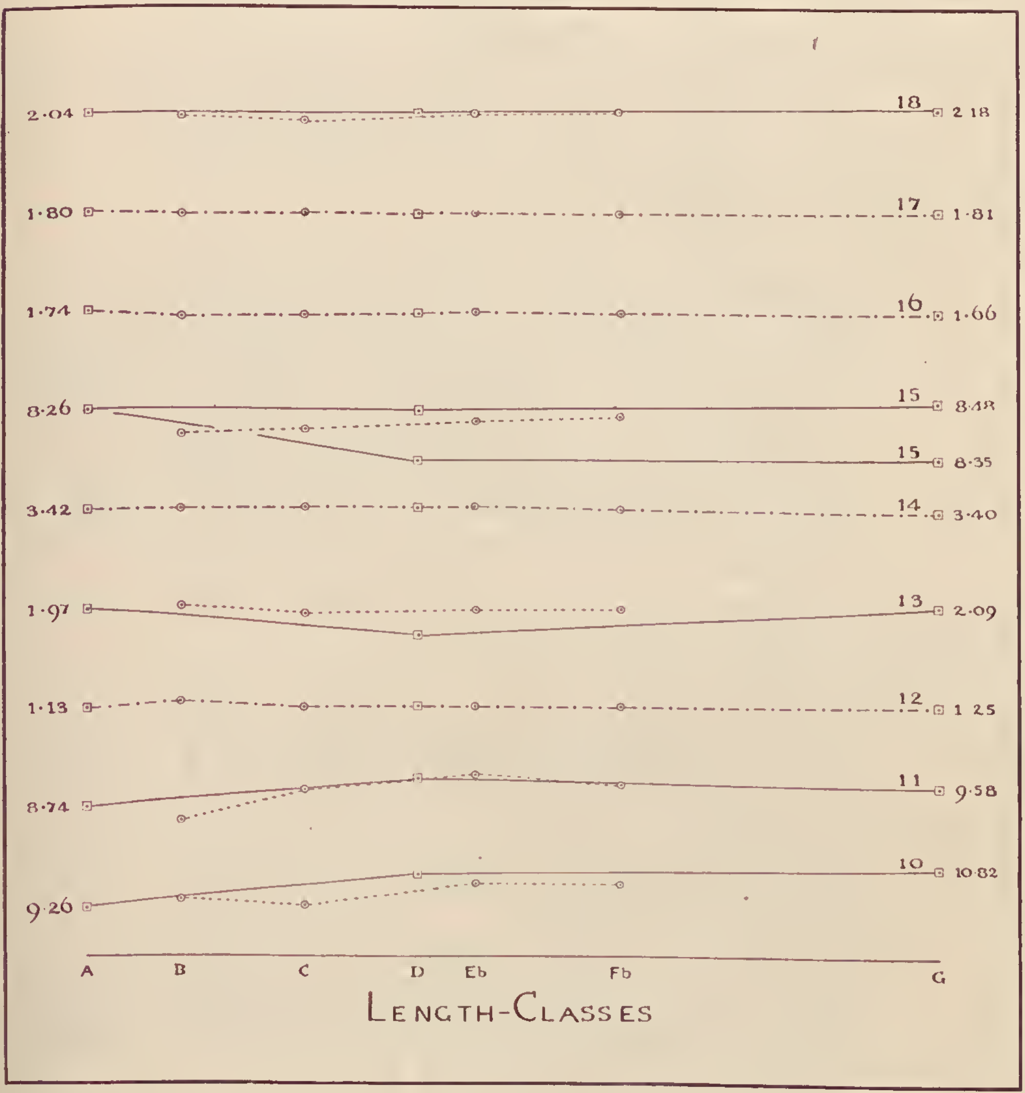
## Plate VIII

School of Pilot Whales, *Globicephalus melas* (Traill, 1809), stranded at Stanley, North Western Tasmania, October, 1935

Some Body Ratios on Standard Length (Continued)

Nine body ratios of seven length-classes (comprising in all 20 individuals) plotted against standard length. Male curve shown by solid line, female curve by line of dashes, pooled curve for both sexes by line of dots and dashes. A separate ordinate is used for each body ratio.

10. Diameter of eye in length to eye.
11. Diameter of eye in length of mouth.
12. Length of mouth in length to blowhole.
13. Length of mouth in length to pectoral.
14. Gonidial angle to eye in length of mouth.
15. Gonidial angle to eye in interocular distance.
16. Length to blowhole in length to pectoral.
17. Length to level of maximum girth in maximum girth.
18. Length to level of maximum girth in length to vent.


2·04
1·80
1·74
8·26
3·42
1·97
1·13
8·74
9·26
18
17
16
15
15
14
13
12
11
10
2 18
1·81
1·66
8·48
8·35
3·40
2·09
1 25
9·58
10·82
A
B
C
D
Eb
Fb
G
LENGTH-CLASSES

# Plate IX

School of Pilot Whales, Globicephalus melas (Traill, 1809), stranded at Stanley, North Western Tasmania, October, 1935

Variation in Proportion with Age: Axial Growth Gradient

Fig. 1.—Variation in Proportion with Age.

Fig. 1*a* males; fig. 1*b* females.

In both diagrams the line $aa_1$ represents mean standard length of minimum length-class, the line $bb_1$ mean standard length of maximum length-class: along each of these lines is plotted the location (as percentage of standard length) of a series of important morphological landmarks, namely, 1, most advanced point on head; 2, eye (anterior margin); 3, blowhole (anterior margin); 4, origin of pectoral; 5, origin of dorsal; 6, level of maximum girth; 7, termination of base of dorsal; 8, vent. Note relative displacement cephalad of these landmarks with increasing age. The postanal region is shaded to emphasize the markedly more rapid rate of growth characterising the portion of the body posterior to, as compared with that anterior to, the vent.

The lines $aa_1$, $\beta\beta_1$, drawn to the same scale in Figs 1*a* and 1*b*, indicate relative standard lengths of classes dealt with.

Fig. 2.—Axial Growth Gradient.

Rate of relative growth ($k_1$) of an axial series of five body regions plotted as ordinates spaced at equal arbitrary intervals, giving a curve of distribution, along the axial line of the animal, of growth potential. Highest point of curve is growth centre.

Regions dealt with are: 1, most advanced point of head to anterior margin of eye; 2, anterior margin of eye to origin of pectoral; 3, origin of pectoral to origin of dorsal; 4, origin of dorsal to vent; 5, vent to caudal notch.

Male curve (based on minimum and maximum length-classes) shown by solid line, female curve (based on minimum and maximum length-classes) by line of dashes, pooled curve for both sexes (based on 10 individuals above, 10 individuals below, the median standard length) by line of dots and dashes.

FIG. 1a

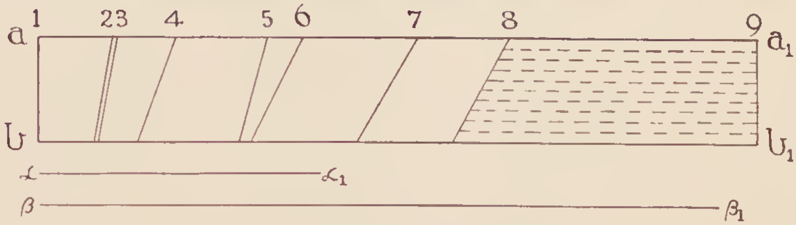



FIG. 1b

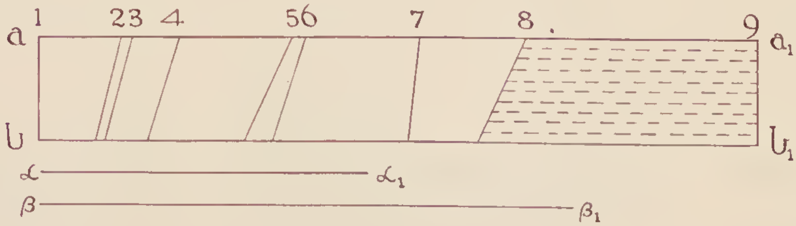
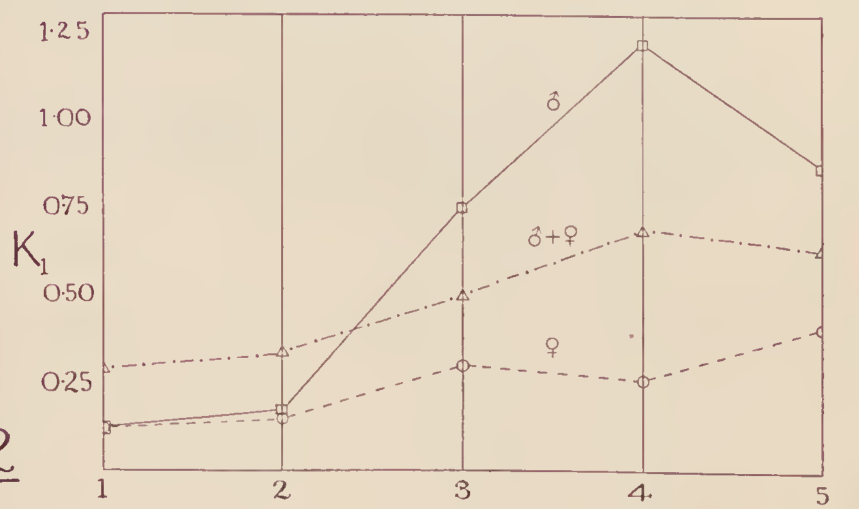



FIG. 2



## Plate X

School of Pilot Whales, Globicephalus melas (Traill, 1809), stranded at Stanley, North Western Tasmania, October, 1935

### Coloration

Fig. 1.—Outline sketch of lateral aspect of a female (specimen no. 7), 380 cm. in standard length, showing location and extent of patch of elephant colour (shaded) near shoulder; outer portion of anterior half of medial postdorsal patch of elephant colour (shaded) also visible. All unshaded regions are black.

Fig. 2.—Outline sketch of right half of dorsal aspect of same individual, showing somewhat pyriform postdorsal patch of elephant colour. Outline of base of dorsal fin cross-hatched. All unshaded or unhatched regions are black.

FIG. 1
FIG 2

## Plate XI

School of Pilot Whales, *Globicephalus melas* (Traill, 1809), stranded at Stanley, North Western Tasmania, October, 1935

Coloration (Continued)

Ventral aspect of a female (specimen no. 7), 380 cm. in standard length, showing light-coloured medial region (note mottling in vicinity of umbilicus), patches of elephant colour flanking the median stripe just in advance of vent, and small patches of mottled elephant colour at bases of pectoral fins. The degree of asymmetry of the colour-pattern indicated approximates the amount of variation observed.